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[THIRD SERIES.]

ART. XXXI.—*Monograph by Professor* MARSH *on the Odontornithes, or Toothed Birds of North America.**

IT is a source of great satisfaction to the friends of science that a discovery which called out at first some incredulity should rest, as Professor Marsh's work shows, on the most complete range of evidence and perfection of material ever at the disposal of the author of a monograph in paleontology. The illustrations on the many beautiful plates of this monograph, instead of being figures of uncharacteristic and scarcely recognizable fragments, as in many memoirs on fossil vertebrates, might be, for the most part, so far as completeness is concerned, representations of recent bones, and, we might almost say, of recent skeletons. In fact, in the case of one species, the type of the genus *Hesperornis*, not more than half a dozen of the small bones are missing; and in *Ichthyornis* and *Apatornis*, also, the remains are remarkably perfect, considering the fragile character of birds' bones. The success of the author in getting together all this so nearly complete material is marvelous, especially when we consider the rare occurrence of Cretaceous fossil birds any where; that only two or three species are known from European Cretaceous beds, and that those are based on fragments that are scarcely characteristic. As a reward for his energy, Professor Marsh has the satisfaction of having obtained, so far as known, all the bird remains that have ever been collected from the Kansas

* *Odontornithes:* A Monograph on the Extinct Toothed Birds of North America; with thirty-four plates and forty woodcuts. By OTHNIEL CHARLES MARSH, Professor of Palæontology in Yale College. 4to, pp. i–xv. 201. Exploration of the 40th Parallel, Vol. VII. Washington, D. C. 1880.

beds, and of having published all the original matter that has yet been brought out on the American Odontornithes.

The present work, which appears as volume VII of the Survey of the 40th Parallel, is also the first of the Memoirs of the Peabody Museum of Yale College. It contains, in its Preface, an outline of the plan of the series to be issued, of which this is the initial volume; and as this subject is one of general interest to paleontological science, we cite the following paragraphs.

"The present volume is the first of a series of monographs designed to make known to science the Extinct Vertebrate Life of North America. In the investigation of this subject, the writer has spent the past ten years; much of it in the field, collecting, with no little hardship and danger, the material for study, and the rest in working out the characters and affinities of the ancient forms of life thus discovered.

"During this decade, the field work, extending from the Missouri River to the Pacific Coast, has so predominated, as the subject unfolded, that a plan of gradual publication became a necessity. The more important discoveries were briefly announced soon after they were made, but only where the specimens on which they were based could be accurately determined. The principal characters of the new groups were next worked out systematically, and published, with figures of the more important parts. When the investigation of a group is completed, the results, with full descriptions and illustrations, will be brought together in a monograph. This system has been carried out with the *Odontornithes*, in the present memoir, and will be continued with the other groups. The investigation of several of these is now nearly completed, and the results will soon be ready for publication.

"The material is abundant for a series of monographs on the marvelous extinct vertebrates of this country, and the results already attained are full of promise for the future. A somewhat careful estimate makes the number of new species of extinct vertebrates, collected since 1868, and now in the Yale College Museum, about 1,000. Nearly 300 of these have already been described by the writer, and some have been noticed or described by other authors, but at least one-third remain to be investigated.

"Among the new groups brought to light by these researches, and already made known by descriptions of their principal characters, are the following, which will be fully described in subsequent volumes of the present series.

"The first Pterodactyles, or flying reptiles, discovered in this country, were found by the writer in the same geological horizon with the *Odontornithes*, described in the present volume.

These were of enormous size, some having a spread of wings of nearly twenty-five feet; but they were especially remarkable for the absence of teeth, and hence resembling recent birds. They form a new order, called *Pteranodontia*, from the type genus *Pteranodon*. Of this group, remains of more than six hundred individuals are now in the Yale College Museum; ample material to illustrate every important point in their osteology.

"With these fossils, were found also great numbers of Mosasauroid reptiles, a group which, although rare in Europe, attained an enormous development in this country, both as to numbers and variety of forms. Remains of more than fourteen hundred individuals, belonging to this order, were secured during the explorations of the last ten years, and are now in the Museum of Yale College.

"The most interesting discoveries made in the Jurassic formation were the gigantic reptiles belonging to the sub-order *Sauropoda*, including by far the largest land animals yet discovered. Another remarkable group of large reptiles found in the same formation were the *Stegosauria*. Other Dinosaurs from the same horizon, the "Atlantosaurus beds," show that this was the dominant form of vertebrate life in that age, and many hundred specimens of these reptiles are now in the Yale Museum. In a lower horizon of the same formation, the "Sauranodon beds," were found the remains of a peculiar new group of reptiles, the *Sauranodonta*, allied to *Ichthyosaurus*, but without teeth.

"In the Eocene deposits of the Rocky Mountains, the writer discovered a new order of huge mammals, the *Dinocerata*. Remains of several hundred individuals were secured, and a monograph on the group will follow the present memoir. In the same formation were found the remains of another new order of mammals, the *Tillodontia*, in many respects the most remarkable of any yet discovered. In the same Eocene deposits were secured the first remains of fossil Primates known from North America, as well as the first Chiroptera, and Marsupialia. Abundant material also was found in the same region to illustrate the genealogy of the horse, and a memoir on this subject is in course of preparation."

We confine our notice of Professor Marsh's volume to a brief résumé of the facts relating to the structure of the Toothed Birds; an account of the interesting facts pertaining to the brains of these ancient birds as compared with the same in related modern kinds; and to a presentation at length, chiefly by quotations from the work, of the author's important biological and paleontological conclusions. These conclusions and many of the facts have not yet been brought out in this Journal.

The Cretaceous deposits of Kansas, which have afforded all the remains of *Odontornithes*, thus far found in America, consist of beds of a fine yellow chalk and a calcareous shale, which have been little disturbed, and to this fact, the wonderful preservation of the fragile bones here described is due. The strata containing them correspond to what has been called by Marsh the "Pteranodon beds," a part of Meek and Hayden's Cretaceous Number 3. This horizon is extremely rich in vertebrate fossils, and contains many fishes, Mosasauroid reptiles, Plesiosaurs and Pterodactyles.

The first specimen of *Odontornithes* found was the distal end of a tibia collected by Professor Marsh in 1870. Other portions of the skeleton were soon afterward brought to light, and the importance of the group being early recognized, an unremitting search for these fossils was kept up for ten years. As the result of this field work, there are now in the Yale Museum more than one hundred individuals of this group, among which are several almost complete skeletons of *Hesperornis* and rich material of *Ichthyornis*.

"A study of this extensive series of Bird remains brings to light the existence of two widely separated types in this class, which lived together during the Cretaceous period, in the same region, and yet differed more from each other than do any two recent birds. Both of these types possessed teeth, a character hitherto unknown in the class of Birds, and hence they have been placed by the writer in a separate sub-class, the *Odontornithes*. One of these groups includes very large swimming birds, without wings, and with the teeth in grooves (*Odontolcæ*), represented by the genus *Hesperornis*. The other contains small birds, endowed with great powers of flight, and having teeth in sockets (*Odontotormæ*), and biconcave vertebræ; a type best illustrated by the genus *Ichthyornis*. Other characters, scarcely less important, appear in each group, and we have thus a vivid picture of two primitive forms of bird structure, as unexpected as they are suggestive. A comparison of these two forms with each other, and with some recent birds, promises to clear away many difficulties in the genealogy of this class, now a closed type; and hence they are well worthy of the detailed description and full illustration here devoted to them."

Hesperornis, the type of the order *Odontolcæ*, was an aquatic bird of great size, measuring almost six feet from the tip of the bill to the end of the toes. Owing to the completeness of the remains, its affinities and probable habits have been very fully and clearly made out.

The teeth had conical pointed crowns covered with smooth enamel and somewhat directed backward, and their fangs were

very stout. In form they closely resemble the teeth of some Mosasauroid reptiles.

There were fourteen functional teeth in the maxillary bone of *Hesperornis regalis*, the premaxillary being edentulous, while in each ramus of the lower jaw there were thirty-three, extending from near the anterior extremity along the entire upper margin of the dentary bone. These teeth were implanted in a continuous groove, and were no doubt held in place during life by cartilage, and thus probably had a slight fore and aft motion. The method of replacement of the teeth was similar to that which obtains in some reptiles. The young tooth was formed on the inner side of the fang of the one which it was to replace, and a pit was there excavated for it by absorption. As it increased in size, the fang of the old tooth became more and more eaten away, and it was finally expelled by the new one, which occupied the same position. Thus the number of teeth always remained the same.

The results of Professor Marsh's investigations of the law of brain growth in Tertiary Mammals are supplemented in a very interesting manner by his study of the brains of these Cretaceous birds, and he concludes that the same principles hold good for them as for the former class.

The brain of *Hesperornis* (figure 1) was very small and was far more reptilian in type than that of any other known bird. The olfactory lobes were large and their nerves passed out of the cranium through separate foramina, one on each side of the interorbital septum. The cerebral hemispheres were small, narrow and elongated, and were separated by a median ridge of bone depending from the roof of the skull. The cerebellum is relatively very large. The optic lobes were large and prominent and present resemblances in size and position to those of reptiles.

Compared with the brain of *Colymbus* (figure 2) the brain of *Hesperornis* presents some interesting features. It was less than one-third the size of that of the Loon, but the most remarkable difference is in the cerebral hemispheres, which in *Colymbus* are much expanded transversely and constitute by far the larger portion of the brain.

The bill of *Hesperornis* was long and slender, and the skull, as a whole, was shaped somewhat like that of the loon, *Colymbus torquatus* Brünnich. The cranium in its more important features presents many resemblances to that of some living Struthious birds, and these point, no doubt, to a real affinity with this group. The neck was long and flexible, the scapular arch very feeble, and there were no functional wings; the only bone of the arm represented being the humerus, which had no articular surface at its distal end. The sternum was broad and

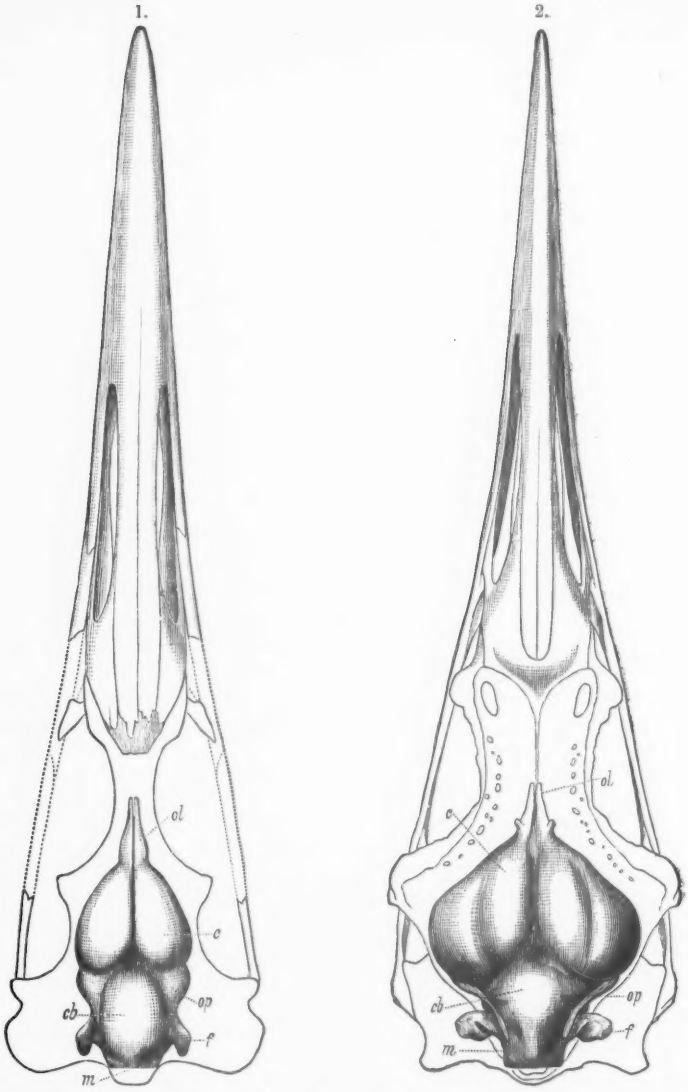

Figure 1.—Outline of skull and brain-cavity of *Hesperornis regalis*, Marsh; seen from above; three-fifths natural size.

Figure 2.—Outline of skull and brain-cavity of the Loon, (*Colymbus torquatus*, Brünnich); same view; natural size.

ol. olfactory lobes; *c.* cerebral hemispheres; *op.* optic lobes; *cb.* cerebellum; *f.* flocculi; *m.* medulla.

long, but was wholly without a keel. The pelvis was greatly elongated and somewhat resembles that of the Grebes. The acetabulum, instead of being a mere ring of bone, as in most birds, is wholly closed internally, with the exception of a foramen perforating the inner wall. The posterior extremities of the ilium, ischium and pubis are free, as in some *Ratitæ* and in *Tinamus*. The tail is long, being composed of twelve vertebræ, a greater number than is found in any recent bird, except possibly the great Auk (*Alca impennis*). The middle and distal caudals have extremely long and widely expanded transverse processes, and by these lateral movement was much restricted, so that the principal motion of the tail must have been vertical, and it was no doubt a powerful aid in diving. The so-called plowshare bone of modern birds is represented by the coössification of the last three or four vertebræ, which, however, form a flat depressed bone not at all resembling its homologue in the bird of to-day.

The legs of *Hesperornis* resemble those of *Podiceps*, and are very large. As they constituted the sole means of locomotion, they had been brought to the highest perfection, but were adapted solely for progression through the water. "Provision was made for a very powerful backward stroke followed by a quick recovery, with little loss by resistance, a movement quite analogous to the strong stroke of an oar, feathered on its return." The motion of the limb was in a vertical plane, but by a peculiar articulation of the digits, present also in some existing diving birds, these members, as the foot was moved forward, were partially rotated so that the narrowest edge of the fourth and longest was brought to the front, and thus the least possible resistance presented to the water. The remaining digits followed behind the fourth, and the foot was not expanded until the beginning of the backward stroke.

Professor Marsh, in his chapter on the Restoration of *Hesperornis*, gives the following among his conclusions with regard to this order:

"*Hesperornis* was a typical aquatic bird, and in habit was doubtless very similar to the Loon, although, flight being impossible, its life was probably passed entirely upon the water, except when visiting the shore for the purpose of breeding. The nearest land at this time was the succession of low islands which marked out the present range of the Rocky Mountains. In the shallow tropical sea, extending from this land five hundred miles or more to the eastward, and to unknown limits north and south, there was the greatest abundance and variety of fishes, and these doubtless constituted the main food of the present species. *Hesperornis*, as we have seen, was an admirable diver, while the long neck with its capabilities of rapid

flexure, and the long slender jaws armed with sharp recurved teeth formed together a perfect instrument for the capture and retention of the most agile fish. As the lower jaws were united in front only by cartilage, as in Serpents, and had on each side a joint which admitted of some motion, the power of swallowing was doubtless equal to any emergency.

"Having thus shown what the skeleton of *Hesperornis* is, and what its mode of life must have been, it remains to consider the more important question of how the peculiar combination of general and specialized characters manifested in its structure originated. The two most striking features of *Hesperornis* are the teeth, and the limbs, and an inquiry in regard to them first suggests itself.

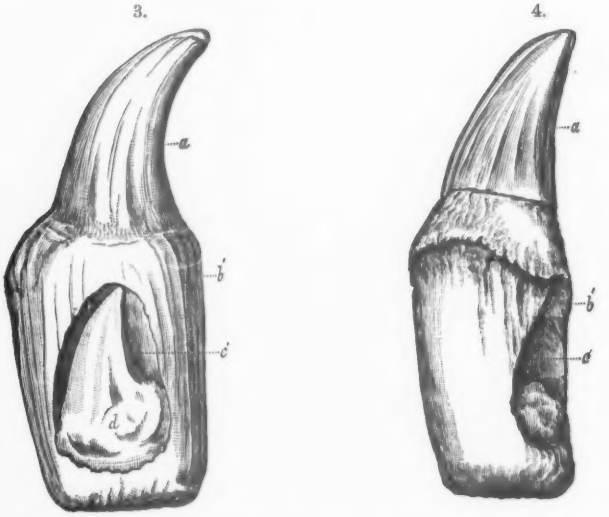

Figure 3.—Tooth of *Hesperornis regalis* (No. 1206); enlarged eight diameters.
Figure 4.—Tooth of *Mosasaurus princeps*, Marsh; half natural size.
a. enamel of crown; *b*. dentine; *b'*. root of tooth; *c'*. absorbed cavity in root; *d*. young tooth.

"The teeth of *Hesperornis* may be regarded as a character inherited from a reptilian ancestry. Their strong resemblance to the teeth of reptiles, in form, structure, and succession, is evidence of this, and their method of implantation in a common alveolar groove (Holcodont), conforms strictly to what we have in one well known group of reptiles exemplified by *Ichthyosaurus*. This method of insertion in the jaw is a primitive dental character, quite different from what we should

naturally expect as an accompaniment of the modern style of vertebra, and is a much lower grade than the implantation of the teeth in distinct sockets (Thecodont), a feature characteristic, as we shall see, of another group of Odontornithes, of which *Ichthyornis* is the type. These teeth indicate unmistakably that *Hesperornis* was carnivorous in habit, and doubtless was descended from a long line of rapacious ancestors."

"In considering the limbs of *Hesperornis*, two explanations of their peculiar modifications naturally suggest themselves. The rudimentary wings, viewed in the light of modern science, clearly indicate that *Hesperornis* was in this respect a degraded type. The Struthious characters which we have noticed in various parts of the skeleton might be regarded, not as evidence of close relationship, but rather as general reptilian characters, common to the two groups through inheritance from a remote reptilian ancestry. According to this view, the wings may have been gradually lost by disuse, after the aquatic life was assumed. In proportion as the wings diminished, the legs and feet increased in size, for their work increased. This change would be strictly in accordance with the law of compensation, and the well known economy of nature. We might suppose, moreover, the ancestors of *Hesperornis* to have been at one time on an equality with the Loon, and later with the Penguin, in respect to means of flight and swimming. As the wings slowly diminished in size, first came the loss of flight, while the wings retained, doubtless for a long time, their power of propulsion through the water. As this too became gradually restricted, the legs and feet gained proportionally. The power derived from them, aided indirectly by the tail, in time so predominated, that the wings became entirely aborted, a remnant of the humerus alone remaining. During the life-history as thus indicated, *Hesperornis* would exemplify in the waters of the Cretaceous period the evolution that has recently taken place in ocean navigation, in the gradual change of the side-wheel steamer into the modern propeller.

"Another explanation seems on the whole more reasonable, and more in accordance with the known facts. The Struthious characters, seen in *Hesperornis*, should probably be regarded as evidence of real affinity, and in this case, *Hesperornis* would be essentially a carnivorous, swimming Ostrich. The diminutive wings and very large posterior extremities would then have been acquired on land, by the same means that have given similar characters to the *Ratitæ*, and subsequently have been adapted to an aquatic life. Against this view, the carnivorous character of *Hesperornis* would be no valid objection. The long neck and peculiar jaws and teeth would be equally effective in seizing prey on the land, and many of the herbivor-

ous cotemporaries would doubtless have been easy victims. This would be precisely analogous to what we have among the corresponding groups in the Dinosaurs.

"There is to-day no evidence that any of the Struthious birds, or their ancestors, ever possessed the power of flight, although this is generally assumed. The case is even stronger with *Hesperornis*, as this genus stands much nearer the ancestral type, both in structure and in time. The absence from the sternum of any trace of a keel is alone strong proof against flight; the peculiar Dinosauroid union of the scapula and coracoid, unlike that of any volant bird or reptile, confirms this; and other testimony bearing in the same direction is not wanting.

"All Carinate birds, moreover, so far as known, indicate by their embryology that they have passed through the Struthious, or lower stage; and some of them, *Tinamus*, for instance, still retain one or more of its general characters. There are, indeed, various flightless birds, recently extinct, which do not belong to the Ostrich group, but are truly Carinate in all their essential features. The Dodo (*Didus*), Solitaire (*Pezophaps*), *Cnemiornis* and *Notornis* are well known examples; but these all show in their shoulder-girdle unmistakable traces of the lost power of flight. The characters necessary to volant movements, once attained, would appear never to be completely lost, and this alone seems to furnish a crucial test. When such suggestive indications are wanting in the skeleton, we may fairly challenge any assumption of previous flight.

"Although *Hesperornis* may thus, like its Reptilian ancestry, have always been incapable of flight, the anterior limbs may have long continued limited aids to locomotion. Whether used actively in the air, like the wings of the Ostrich, or of young swimming birds, or passively, like the sail-set pinions of a Swan, or later as imperfect paddles, the wings of *Hesperornis* were certainly not well fitted for diving, and hence they gradually became useless, and virtually disappeared. We may imagine among the reasons for the gradual loss of wings, the fact that they were too weak to be of much service under water, while from their position they added greatly to the resistance, especially during rapid diving. To diminish this resistance, they would naturally be applied closely to the side, and from such disuse, would gradually suffer atrophy.

"In this great swimming bird, as thus modified, we have presented to us an interesting problem in animal mechanics. The wings may be regarded as wanting, since the remnant of the humerus was attached closely to the side, as in *Apteryx*, if not entirely concealed beneath the skin, like a scapula. The locomotion was therefore entirely performed by means of the

posterior limbs, a specialization here seen for the first time in aquatic birds, recent or fossil. Those who have observed a Penguin or a Loon swimming beneath the water know what a vigorous use such birds then make of their wings, however useless these members may appear to be on land. Not only do the wings, in such a case, assist in the forward movement through the water, but they are of much service in steering. A Penguin, when in swift sub-aqueous flight, can turn around, by the aid of its wings, while moving twice its length. *Hesperornis* had no such aid, but the legs and feet were far superior, for swimming and diving, to those of the Penguins, not merely in power, but in the more perfect adaptive mechanism. This was doubtless the main reason why the posterior limbs of *Hesperornis* became so predominant.

"The tail of *Hesperornis* was clearly of great service in its aquatic life. In the number of vertebræ and length, it exceeds nearly all known birds, and it is unique in its widely expanded transverse processes, and in its depressed, horizontal, plough-share bone. This broad horizontal tail reminds one of that of the beaver, and was undoubtedly of great assistance in steering and in diving. Whether it was, like the beaver's tail, destitute of feathers, or, like the tail of *Plotus*, was furnished with long stiff feathers, so as to act as a rudder, cannot at present be determined with certainty, although the latter view seems more probable. That *Hesperornis* was provided with feathers of some kind, we can hardly doubt."

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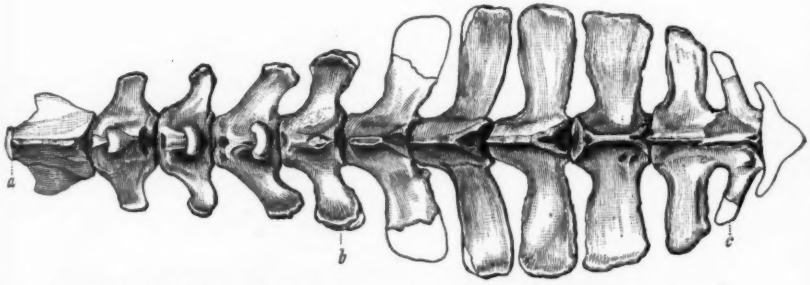

Figure 5.—Caudal vertebræ of *Hesperornis regalis*, Marsh; seen from above, in position; two-thirds natural size.

It is interesting to observe that Professor Marsh, working from an entirely different standpoint, reaches the same conclusions that were arrived at by Haughton with regard to the volant powers of Struthious birds. The latter, from his studies of the myology of the wings of the *Ratitæ*, concludes that these birds could never have possessed the power of flight. The

gradual atrophy of the arm resulting from disuse, the extreme of which is seen among living birds in *Apteryx*, had proceeded so far in *Hesperornis* that it was no better provided with fore limbs than are the Cetaceans with hind limbs.

The enormous development of the legs and feet, supposed by some writers to point to an affinity with the *Pygopodes*,

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Figure 6.—Restoration of *Hesperornis regalis*, Marsh. One-eighth natural size.

does not really suggest any such relationship. That the legs are much alike in both groups is true; but to suppose that *Hesperornis* is merely a loon or grebe with teeth, is to take a very superficial view of the structural characteristics

of this type. The feet and legs are purely adaptive, and have simply been developed into most perfect instruments for progression through the water. That these members in another and widely different group of birds should have proceeded along the same path of development is nothing surprising and is paralleled in several other groups of vertebrates.

The order *Odontotormæ*, described in Part II of Professor Marsh's work, is represented by two genera, *Ichthyornis* and *Apatornis*. These birds were small and wholly unlike *Hesperornis* in structure, being, perhaps, as different from that type as from that of any modern birds. They were about the size of a pigeon and were provided with very large strong wings, but had small legs and feet. The sternum is strongly keeled, and the bones are extensively pneumatic. They present some resemblances in structure to the existing Terns, and are thought to have somewhat resembled those birds in their mode of life.

The teeth of *Ichthyornis* and *Apatornis* were implanted in distinct sockets, instead of in a groove, as in *Hesperornis*. They are somewhat compressed and strongly recurved, and the cutting edges in front and behind are sharp and smooth, without serrations. The teeth in the maxillary seem to have been larger than those opposed to them. In *Ichthyornis dispar*, the type of the order, there were twenty-one teeth in the lower jaw. The anterior one is very near the extremity of the jaw and from this point they extend back to the posterior extremity of the dentary. The method of replacement of the teeth was not lateral, as in *Hesperornis* and the Mosasaurs, but vertical, as in the Crocodiles and Dinosaurs—an important and highly interesting fact.

An examination of the brain cavity of *Ichthyornis* presents results similar to those arrived at from the comparison of the same part in *Hesperornis*. If we compare the skull of *Ichthyornis* with that of *Sterna*—the two being reduced to the same absolute size—we find the brain of the former to have been less than one-third the size of the latter. The differences between these two smaller birds are the same in kind as those between *Hesperornis* and *Colymbus* (figures 1 and 2), but the cerebral hemispheres in *Ichthyornis* are relatively less elongated than in its Cretaceous contemporary.

The similarity in the results of these comparisons is especially interesting, since in no other cases have the brain cavities of Mesozoic birds been studied.

A feature of this group, not less interesting than the possession of teeth, is their biconcave vertebræ. The presence of this reptilian character in vertebrates so highly organized as birds, was wholly unexpected, and is only another illustration of the fact, so constantly obtruded upon the attention of the

anatomist, that some low character may persist while specialization in certain directions is reaching a high degree of perfection. If we leave out of account the skull and presacral vertebræ of this group, its structure is essentially that of a modern bird, but the combination of such specialized and primitive characters renders it not less remarkable than its larger toothed ally.

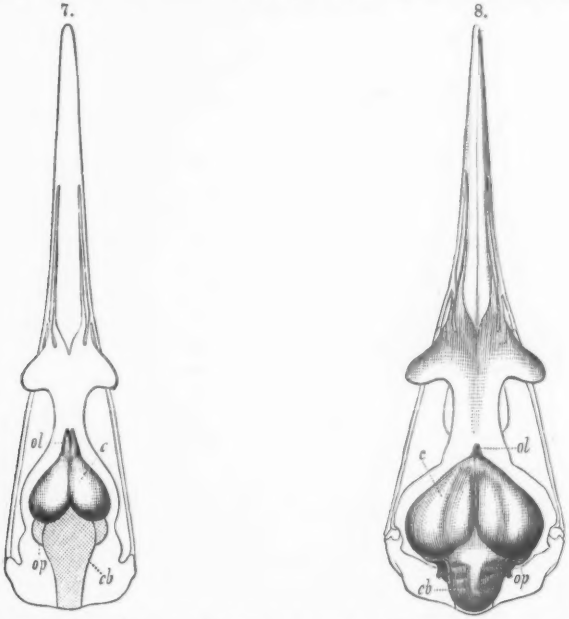

Figure 7.—Outline of the skull and brain-cavity of *Ichthyornis victor*, Marsh; seen from above; five-sixths natural size.

Figure 8.—Outline of the skull and brain-cavity of *Sterna cantiaca*, Gmelin; same view; natural size.

ol. olfactory lobes; *c.* cerebral hemispheres; *op.* optic lobes; *cb.* cerebellum.

With respect to *Ichthyornis* as a whole, Professor Marsh says:

"In considering the skeleton of *Ichthyornis*, the anatomist is at once confronted with a strange combination of characters. The wing-bones are conclusive proof that *Ichthyornis* was a highly specialized bird, with great powers of flight. The individual bones correspond closely with those of birds living to-day. The legs and feet, also, are much like those of some modern birds. With these portions alone before him, the comparative anatomist would unhesitatingly refer the remains to the class of Birds, and would naturally conclude that they belonged to the modern type. If, however, the skull should then be found with the wings and feet, very strong evidence

would be required to convince him that they were parts of one and the same bird. The jaws and teeth present reptilian characters wholly unknown in modern birds, while the base of the skull and the small brain point strongly in the same direction. The biconcave vertebræ lead *Ichthyornis* still farther away from all known birds, recent and extinct, and, if found alone with the jaws and teeth, would force any anatomist to the conclusion that he had before him the remains of a reptile.

"The skeleton of *Ichthyornis*, as we know it to-day, can be interpreted only, in the light of modern science, by supposing that certain parts have become highly specialized in the direction of recent birds, while others have been derived, with but little change, from a reptilian, or even a more lowly, ancestry. In the wings, the most characteristic modern feature is the coössification of the metacarpal bones, a character universal among existing birds. In reptiles, however, and in the only known Jurassic bird, *Archæopteryx*, these bones are separate. The sternum of *Ichthyornis* is very similar to that of modern carinate birds. In the feet of *Ichthyornis*, also, the compound tarso-metatarsal is another modern feature, especially characteristic of recent birds.

"If, now, we consider the skull of *Ichthyornis*, we find the avian and the reptilian characters strangely blended. The teeth are evidently a strong reptilian feature, and, before the discovery of *Ichthyornis*, were entirely unknown in the class of Birds. Their method of implantation in distinct sockets is a specialized character in reptiles, and was not shared even by *Hesperornis*, the contemporary of *Ichthyornis*. The diminutive elongated brain, also, points back to the reptiles. Other features of the skull, for example, the single headed quadrate, are shared only by the most reptilian of birds. The union of the lower jaws in front, by ligament only, is characteristic of many reptiles, and is seen in *Hesperornis*, but is unknown in all other birds. The form of the skull and the obliteration of most of the cranial sutures are points of resemblance to many modern birds.

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"In considering the mode of life, and habits of *Ichthyornis*, many important suggestions may be derived from its structure, as well as from the localities where the remains are found. The sharp cutting teeth of *Ichthyornis* prove, beyond a doubt, that it was carnivorous; its great powers of flight, long jaws, and its recurved teeth suggest, moreover, that it captured its prey alive. Its food was probably fishes, as their remains are found in great abundance mingled with those of *Ichthyornis*. These fossils occur in the bed of the old Cretaceous ocean in

which *Hesperornis* swam. Both of these birds were clearly aquatic in habit, as shown by various points in their structure, already described, and the conditions under which their remains were deposited. In many respects, *Ichthyornis* probably resembled the modern Terns in its mode of life. The powerful wings and small feet suggest similar habits in flight, and rest.

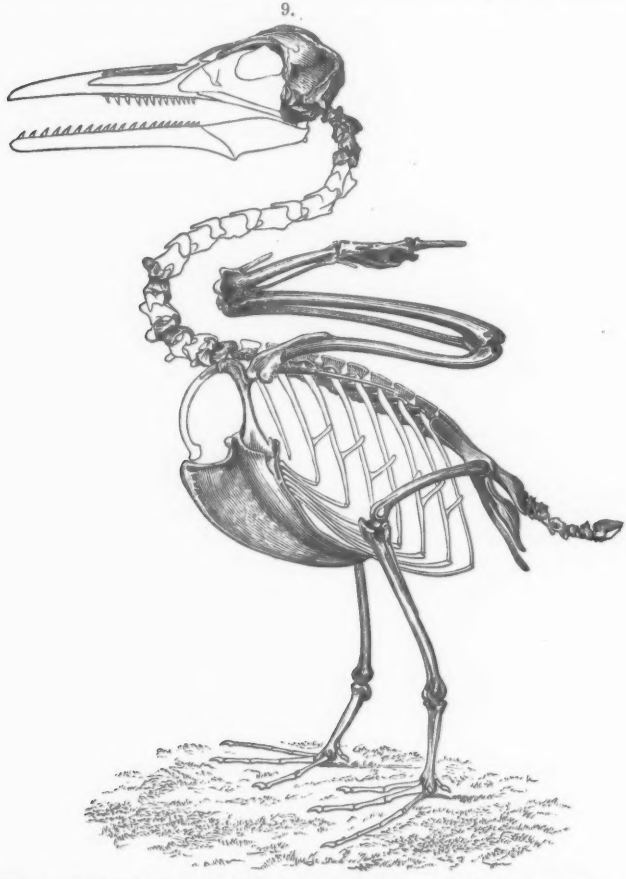


Figure 9.—Restoration of *Ichthyornis victor*, Marsh. One-half natural size.

That *Ichthyornis* was provided with feathers is proved beyond question by the tubercles for the attachment of quills on the forearm.

"Besides *Ichthyornis* and its allies, the only other denizens of the air at present known to have then inhabited the same

region were the toothless Pterodactyles. *Ichthyornis* doubtless competed with these huge dragons for the fishes in the tropical ocean about which they lived."

The discovery of these two ancient types of birds, so widely different from each other and from all known members of the class, gives us, as might be expected, many hints as to the genetic origin of birds, and proves especially interesting as confirming the generally accepted view of the close relationship between birds and reptiles. These two types with *Archæopteryx* and *Compsognathus* lead us directly back from the birds of today to the reptiles of Mesozoic, if not of still earlier, time. While other Cretaceous birds have been described both from this country and from Europe, only the *Odontornithes* are represented by remains sufficiently perfect to warrant us in drawing any satisfactory conclusions in regard to their relationship with other members of the class. And only through the discovery of their remains in such a wonderful state of preservation, could we have learned how extremely unsafe it is to generalize from single bones or portions of a skeleton, no matter how characteristic they may appear to be. The discoverer who should find only the legs and vertebræ of *Hesperornis* would be justified in assigning to them a place very near the existing *Podicipidæ*, and the conclusion would be sustained by the judgment of every anatomist. Or, if the skeleton of *Ichthyornis* were discovered without the skull and anterior vertebræ, no one would find any characters to warrant the separation of this form from our modern birds. On the other hand, an examination of the skull in either form, the remainder of the skeleton being unknown, might well lead the student as far from the truth in the other direction. So untrustworthy, in the light of modern science, has Cuvier's law of correlation proved to be.

The conclusions drawn by Professor Marsh from his study of all the known remains of *Odontornithes* are as follows:

"Having now described the more important characters in the structure, so far as known, of the two groups of Cretaceous *Odontornithes*, or Birds with teeth, it remains to consider what relation these birds bear to each other, and to allied members of the class; and, also, to inquire if the facts presented throw any light on the profounder question as to the origin of Birds.

"In comparing *Hesperornis* and *Ichthyornis*, as the types of their respective orders, the *Odontolcæ* and *Odontotormæ*, the contrast in their principal characters is as striking as it is unexpected. *Hesperornis* had teeth implanted in a continuous groove, a low, generalized character; with, however, the strongly differentiated saddle-shaped vertebræ. *Ichthyornis*, on the other hand, had the primitive biconcave vertebræ, and yet

the highly specialized feature of teeth in distinct sockets. Better examples than these could hardly be found to illustrate one fact brought out by modern science, that an animal may attain great development in one set of characters, and at the same time retain other low features of the ancestral type. This is a fundamental principle of evolution.

"The more superficial characters of the absence of wings and the strong swimming legs and feet of *Hesperornis* are in striking contrast, also, with the powerful wings and diminutive legs and feet of *Ichthyornis*. These and other characters, already mentioned, separate the two birds so widely that a more detailed comparison seems here unnecessary.

"It would be highly desirable to carefully compare both *Ichthyornis* and *Hesperornis* with *Archæopteryx*, the still older Mesozoic bird. This unfortunately cannot be done at present, as the two skeletons of *Archæopteryx*, now known, have not yet been fully described, nor even prepared for examination by removal of the matrix. That *Archæopteryx* belongs to the *Odontornithes*, the writer fully satisfied himself by a personal examination of the well known specimen in the British Museum. This examination was made in 1878, several years after the writer had become familiar with the American forms of toothed birds. The teeth seen on the same slab with this specimen of *Archæopteryx*, and referred to it by Evans, although imperfectly preserved, agree so closely with the teeth of *Hesperornis*, that the writer identified them at once as those of Birds, and not of Fishes. It has since been announced that the specimen of *Archæopteryx*, more recently found in Germany, also possessed teeth, although only two of small size were detected. The separate metacarpal bones, and especially the elongated tail, of *Archæopteryx*, moreover, remove it widely from the known American genera of *Odontornithes*. It will probably be found, however, that *Archæopteryx* possessed biconcave vertebræ, something like those of *Ichthyornis*.

"The other Mesozoic birds now known from the deposits of this country, and the few discovered in Europe, may, some or all of them, have had teeth, but their remains are too fragmentary to determine this point, or even their near affinities.

"It is an interesting fact that the Cretaceous birds at present known, some twenty species or more, were all apparently aquatic forms, which of course are most likely to be preserved in marine deposits, while the Jurassic *Archæopteryx*, the only one from that formation, was a true land bird.

"The birds found in more recent formations all belong apparently to modern types, and hence present few points for profitable comparison with the *Odontornithes*. The existing birds with reptilian characters are nearly all confined to the *Ratitæ*,

or Ostrich tribe. These are evidently the remnants of a very numerous group, once widely extended over different parts of the earth; and it is to the fossil forms of these birds that we must look eventually for the intermediate types between them and the less specialized Mesozoic birds.

"For the present, at least, it seems advisable to regard the *Odontornithes* as a sub-class, and to separate them into three orders, according to the characters given below. These orders are all well marked, but evidently are not of equal rank. *Archæopteryx* is clearly separated much more widely from both *Ichthyornis* and *Hesperornis* than are these two genera from each other. The free metacarpals and long tail of *Archæopteryx* are significant characters. Gegenbaur and Morse, however, have shown that young birds of existing species have the metacarpals separate, and this is true for all these birds up to a certain age. Hence this character is of less importance than the presence of true teeth, since in no recent birds, young or old, have these been found. The length of tail is perhaps a character of more value, but this is a variable feature in modern birds.

Sub-class ODONTORNITHES (or AVES DENTATÆ), Marsh.

Order, ODONTOLCÆ, Marsh.	ODONTOTORMÆ, Marsh.	SAURURÆ, Hæckel.
Genus, *Hesperornis*, Marsh.	*Ichthyornis*, Marsh.	*Archæopteryx*, von Meyer.
Teeth in grooves.	Teeth in sockets.	Teeth in ——— ?
Lower jaws separate.	Lower jaws separate.	Lower jaws ——— ?
Vertebræ saddle-shaped.	Vertebræ biconcave.	Vertebræ ——— ?
Wings rudimentary.	Wings large.	Wings small.
Metacarpals wanting.	Metacarpals ankylosed.	Metacarpals separate.
Sternum without keel.	Sternum with keel.	Sternum ——— ?
Tail short.	Tail short.	Tail longer than body.

"That the three oldest known birds should differ so widely from each other points unmistakably to a great antiquity for the class. *Archæopteryx*, *Hesperornis* and *Ichthyornis*, are all true birds, but the reptilian characters they possess are convergent toward a more generalized type. No Triassic birds are known, and hence we have no light on this stage of the development of the class. They will doubtless be found, however, and, if we may judge from Jurassic Mammals and Reptiles, the next classes above and below birds, the avian forms of that period would still be birds, although with even stronger reptilian features. For the primal forms of the bird-type, we must evidently look to the Paleozoic; and in the rich land fauna of our American Permian we may yet hope to find the remains of both Birds and Mammals.

"The genera *Archæopteryx*, *Hesperornis* and *Ichthyornis*, each possessed certain generalized characters not shared by the others. These characters were undoubtedly united in some

earlier form, and this fact gives us a hint as to what the more primitive forms must have been, and suggest the more prominent features of the ancestral type.

"In the generalized form to which we must look back for the ancestral type of the class of birds, we should therefore expect to find the following characters:

(1.) Teeth, in grooves.
(2.) Vertebræ biconcave.
(3.) Metacarpal and carpal bones free.
(4.) Sternum without a keel.
(5.) Sacrum composed of two vertebræ.
(6.) Bones of the pelvis separate.
(7.) Tail longer than the body.
(8.) Metatarsal and tarsal bones free.
(9.) Four or more toes, directed forward.
(10.) Feathers rudimentary or imperfect.

"These various characters may indeed have been combined in an animal that was more reptile than bird; but such a form would be on the road toward the Birds, rather than on the ancestral line of either Dinosaurs or Pterodactyles, as feathers were not a character of these groups. With this exception, all of the characters named belong to the generalized Sauropsid, from which both birds and the known Dinosaurs may well have descended. An essential character in this ancestral type would be a free quadrate bone, since this is a universal feature in birds, and only partially retained in the Dinosaurs now known.

"The Birds would appear to have branched off by a single stem, which gradually lost its reptilian characters as it assumed the ornithic type, and in the existing Ratitæ we have the survivors of this direct line. The lineal descendants of this primal stock doubtless early attained feathers and warm blood, but, as already shown, never acquired the power of flight. The volant birds doubtless separated early from the main avian stem, probably in the Triassic, since, in the formation above, we have *Archæopteryx*, with imperfect powers of flight.

"This power of flight probably originated among the small arboreal forms of reptilian birds. How this may have commenced, we have an indication in the flight of *Galeopithecus*, the flying squirrels (*Pteromys*), the flying lizard (*Draco*), and in the flying tree-frog (*Rhacophorus*). In the early arboreal birds, which jumped from branch to branch, even rudimentary feathers on the fore limbs would be an advantage, as they would tend to lengthen a downward leap, or break the force of a fall. As the feathers increased, the body would become warmer, and the blood more active. With still more feathers, would come increased power of flight, as we see in young birds of to-day. A greater activity would result in a more

perfect circulation. A true bird would doubtless require warm blood, but would not necessarily be hot-blooded, like the birds now living.

"The short wings and clumsy tail of *Archæopteryx* were quite sufficient for short flights from tree to tree, and if the body were essentially naked, as now supposed, we have in this Jurassic form an interesting stage in the development of birds before full plumage was attained. Whether *Archæopteryx* was on the true Carinate line cannot at present be determined, and this is also true of *Ichthyornis;* but the biconcave vertebræ of the latter evidently suggest that this form was an early offshoot. It is probable that *Hesperornis* came off from the main Struthious stem, and has left no descendants.

"These three ancient birds, so widely different from each other, and from all modern birds, prove beyond question the marvelous diversity of the avian type in Mesozoic time; and also give promise of a rich reward to the explorer who successfully works out the life-history of allied forms, recorded in ages more remote."

The discovery of birds so highly specialized in certain directions as are the *Odontornithes*, certainly points to a much earlier origin than has hitherto been acknowledged for this class, and we are not surprised that Professor Marsh suggests that the original bird stem branched off from the reptiles during Paleozoic time. In view of the results of the past ten years' investigations upon this and kindred points, we may fairly hope that future discoveries will add much to our knowledge of this subject as well as to our comprehension of the relations existing between the three ancient types of birds, *Hesperornis*, *Ichthyornis*, and *Archæopteryx*, and the two existing ones, *Carinatæ* and *Ratitæ*.

Paleontologists will look forward with much interest to a comparison of *Archæopteryx* with the *Odontornithes*. This will no doubt be made as soon as full descriptions and figures of the recently discovered specimens of the former shall have been published. That it is widely different from the Cretaceous toothed birds is sufficiently apparent, but it will be most interesting to learn what other primitive characters besides teeth it has in common with this group.

Too much cannot be said in praise of the mechanical execution of the present volume. The plates are marvels of drawing, and present to the eye an absolutely accurate representation of the bones figured. We cannot do better than repeat Professor Geikie's remark in regard to them. He says:— "They are strictly and rigidly scientific diagrams, wherein every bone and part of a bone is made to stand out so clearly that it would not be difficult to mold a good model of the skel-

eton from the plates alone. And yet with this faithfulness to the chief aim of the illustrations there is combined an artistic finish which has made each plate a kind of finished picture."

Professor Marsh's volume on the *Odontornithes* stands almost if not quite alone among works on fossils, as regards the completeness of the material described and figured, the paleontological interest attaching to this material, and the importance of the biological conclusions drawn from it. As the first volume of the Memoirs of the Yale Museum, it gives a rich promise of what we may hope to see when the extensive collections at New Haven shall have been fully investigated.

GEO. BIRD GRINNELL.

ART. XXXII.—*On some Elements in Orographic Displacement;* by W. J. McGEE.

IN his masterly treatise on the "Systematic Geology of the Fortieth Parallel," Clarence King has succinctly outlined many of the fundamental elements in orographic disturbance; but a series of factors doubtless predominant in some cases seems to have been overlooked. It is shown (pp. 728, 746, and elsewhere), in the case of the Wahsatch region, (*a*) that the gradual submergence of an area of deposition was followed by paroxysmal upheaval, (*b*) that in the contiguous area of degradation gradual elevation was succeeded by paroxysmal submergence, and (*c*) that the original locus of fracture remained a line of weakness and of recurrent displacement throughout the whole of the geological history of the region; and these phenomena seem to be considered anomalous and inexplicable.

To the writer the phenomena described seem to be in perfect harmony with established physical principles; and, in their simplicity and uniformity of action through vast periods, to accord most fully with the regularity and general conformity in the succession of events everywhere attested by the magnificent section so well described in the work mentioned. This will appear from the following analysis, in which, for the sake of simplicity, all disturbing factors are disregarded, and a high degree of uniformity in the character of the earth's crust assumed. It is believed, however, after a careful scrutiny, that essentially identical results would follow the most rigid analysis.

The solid crust of the earth may be assumed to consist of three layers of equal thickness (which may be designated as *n*, *o*, and *p*), but of density varying as $2d$, $3d$, and $4d$ respectively, resting upon a mobile substratum.* Tangential strain due to

* The "critical shell" of Mr. King might be equivalent to such a mobile substratum.

contraction of the globe might give rise to a fault, which, as indicated not only by physical considerations but also by the testimony of existing faults, would form an angle with the vertical. At the same time the region (A) on the side of the fault forming an acute angle with the surface would be upheaved, and the region (B) on the opposite side depressed. Such a displacement might altogether relieve the tangential strain. The elevation and depression on opposite sides of the fault may each be assumed to equal n. Suppose now the upheaved portion of region A to be removed by denudation and deposited within the depressed region B. The thickness of the crust at A and B will then be $o+p$ and $n+n+o+p$ respectively. The effects of radial and tangential strain may now each be considered separately.

Over region A the weight of the solid crust would be but $3d+4d$, while over B it would be $2d+2d+3d+4d$. In the effort of the continuous and slightly flexible crust to assume statical equilibrium the absolutely heavier region would undergo a further depression, while the lighter area would be correspondingly elevated, as long since shown by Babbage, Herschel, Hall, and others. This movement would be counteracted and retarded by the rigidity of the crust, and would tend to produce rupture in the vicinity of the original fault. If now rupture supervene, the two regions will become comparatively independent bodies resting upon the mobile substratum; and each will assume the position due to its density relative to that of the substratum. But since the density of region A is $\frac{3d+4d}{2}$, while that of region B is only $\frac{2d+2d+3d+4d}{4}$, it is obvious that the former region will be depressed and the latter elevated; and the relative elevation of the two regions will accordingly be reversed, and in a paroxysmal manner. If subsequent movements are now considered it will be seen that, if only radial strain is taken into account, the tendency is toward an alternate series of successive and unequal, but constantly diminishing and mutually approaching, elevations and depressions on each side of the original locus of displacement, each paroxysmal in its nature and occurring at the close of a period of comparative repose and quiet sedimentation.

Since the secular refrigeration of the globe would eventually re-introduce tangential strain, its effect upon the crust, at the stage when fracture was supposed to be imminent in the last case, may be considered. Manifestly, when the pressure became sufficient to produce fracture, the crust would give way at its thinnest and weakest point; but the precise plane of dislocation would be determined in a great measure by the incipient tendency to bend upward or downward. Now since the previous

dislocation had perhaps equally shortened the chord of region B and lengthened that of A, there might be an equal tendency upward in B and downward in A; but the crust being weakest in A, and near to the original locus of displacement (where erosion would naturally be greatest), here the rupture would be likely to occur; and on account of the downward tendency of A, this region would be depressed. In this case, as in the last, therefore, the relative elevation of the two regions would be reversed. The tendency toward a succession of similar displacements is the same also as in the last case, provided secular refrigeration went on, except that there would be no diminution in intensity. The coördination of the two forms of pressure would tend to prolong the series of disturbances, and, if the relation between the rates of degradation and secular cooling remained constant, to perpetuate them.

Though the rise of the iso-geothermal planes below region B and their depression under A brought about by the deposition and erosion in these regions respectively (which movement was long ago pointed out by Babbage and Herschel, and has been considered by Hall, Hunt, Dana and LeConte to explain the formation of mountain flexures in areas of antecedent deposition) has been disregarded in the above analysis, the results of such movements are important. Obviously, if the shifting of the iso-geotherms kept pace with the degradation of A and the sedimentation in B, the portion of the rigid crust forced below the normal position of p would be rendered mobile, while that part of the mobile substratum forced above the same plane would be made rigid (the mobility being assumed to vary with the temperature). In such a case none of the results above indicated would follow. But since the rapid conduction of heat from ocean bottoms (which has recently been considered by Milne* and others) tends to prevent the rise of the iso-geotherms beneath regions of deposition, and since, further, the thermal effect of any surface revolution can only be conveyed far beneath the surface after a considerable interval, it seems probable that the results indicated above might or might not follow according as local conditions were favorable or otherwise. These conditions (including the rates of erosion and deposition, specific heat and conductivity of the rocks, etc.), are so complex and so imperfectly understood that it seems impossible to determine *a priori* whether or not the above detailed results would follow in any given case.

Farley, Iowa, Sept. 8th, 1880.

* Geol. Mag., II, vii, 169.

ART. XXXIII.—*On the Indices of Refraction of certain Compound Ethers;* by JOHN H. LONG.

ABOUT two years ago, while at work in the laboratory of the University of Tübingen, I undertook the determination of the Indices of Refraction of a number of Ethers of the $C_nH_{2n}O_2$ series. This work was commenced at the suggestion of Professor Lothar Meyer, who was at the same time engaged in an investigation concerning the rates of transpiration of these and other bodies. It might also be remarked that the same substances were being used by Herrn Emil Elsässer for the determination of specific gravity and coefficient of expansion, and his results I have made use of in the calculation of the tables found below.

Other duties prevented the publication of my results at the time, but the elegant work of Brühl,* which has since appeared, having added a new interest to the subject of refraction, I deem it not too late to make them known now. The method employed was essentially that of Landolt.† A large Meyerstein spectrometer, kindly loaned me by Professor v. Reusch of the Tübingen physical laboratory, permitted results exact to four decimal places of n (as explained below) to be readily obtained. The fifth decimal place is in most cases uncertain.

As source of light I used the sodium flame and the refractive indices for the D line were determined for several different temperatures. This was accomplished as follows: The hollow glass prism containing the liquid to be examined, together with its metallic support, was placed on a hot iron plate and left there until the temperature of the liquid had risen (in most cases) to about 30° C., as shown by the small thermometer firmly secured by a cork in the orifice of the prism. Then the prism and support were replaced on the spectrometer, allowed to remain a few minutes, when the final adjustments were made and the observations commenced. The readings were made from degree to degree, and continued until the temperature of the liquid in the prism had fallen to that of the room. The thermometer used had been previously carefully compared with a normal thermometer in the possession of Professor Meyer and a table of corrections thus obtained, so that the temperatures given may be looked upon as exact to 0·1°.

The indices were determined by the method of minimum deviation, according to the formula

* J. W. Brühl: Die chemische Constitution organischer Körper in Beziehung zu deren Dichte u. Vermögen d. Licht fortzupflanzen. Liebig's Annalen, cc, 139; cciii, 1, 255 and 363. See also this Journal, Jan., 1881, page 70.

† Pogg. Ann., Bd. cxvii, 353.

$$n = \frac{\sin \frac{A+d}{2}}{\sin \frac{A}{2}}$$

where d is the observed angle of minimum deviation and A the refractive angle of the prism. This latter was determined before each observation (as the sides of the prism were formed of glass plates fastened by rubber bands) and varied between 60° 2′ 30″ and 60° 3′ 30″.

In every case at least two complete sets of observations were made for each substance and the mean of the results, which never showed variations beyond the fifth decimal place, was taken. The following table contains these results.

Under *T* I have given the temperature in degrees Cent. at which the observations were made. Under *n* are given the indices, and under *diff.* the variations in the same for a change in temperature of one degree. In every case the boiling point of the ether in question is given, and when the same was determined under diminished pressure, this latter element is given. In other cases the usual barometric height in Tübingen—about 735^{mm}—is to be understood.

Methyl formate.

Bp = 32°·8

T.	*n*.	diff.
20	1·34386	
19	1·34430	·00044
18	1·34473	43
17	1·34516	43
16	1·34559	43
15	1·34601	42

Propyl acetate.

Bp = 87°·8–88°·2 P, 470^{mm}

T.	*n*.	diff.
22	1·38352	
21	1·38404	·00052
20	1·38456	52
19	1·38507	51
18	1·38558	51
17	1·38608	50

Propyl formate.

Bp = 67°–67°·3 P, 431^{mm}

T.	*n*.	diff.
23	1·37604	
22	1·37656	·00052
21	1·37706	50
20	1·37756	50
19	1·37806	50
18	1·37855	49
17	1·37904	49

Methyl propionate.

Bp = 79°·5–80°

T.	*n*.	diff.
20	1·37763	
19	1·37822	·00059
18	1·37875	53
17	1.37927	52
16	1·37980	53
15	1·38032	52

Isobutyl formate.

Bp = 99°–99°·4

T.	*n*.	diff.
22	1·38641	
21	1·38693	·00052
20	1·38745	52
19	1·38796	51
18	1·38845	49
17	1·38893	48
16	1·38941	48

Ethyl propionate.

Bp = 81°·4–82° P, 402^{mm}

T.	*n*.	diff.
20	1·38421	
19	1·38471	·00050
18	1·38520	49
17	1·38568	48
16	1·38616	48
15	1·38663	47

PROPYL PROPIONATE.

Bp = 101°·5–102° P, 384mm

T.	*n*.	diff.
23	1·39199	
22	1·39253	·00054
21	1·39305	52
20	1·39356	51
19	1·39405	49
18	1·39452	47
17	1·39497	45

ISOBUTYL PROPIONATE.

Bp = 135°·2–135°·5

T.	*n*.	diff.
20	1·39748	
19	1·39793	·00045
18	1·39838	45
17	1·39882	44
16	1·39925	43

AMYL PROPIONATE.

Bp = 159°·5–160°

T.	*n*.	diff.
23	1·40523	
22	1·40567	·00044
21	1·40610	43
20	1·40653	43
19	1·40696	43
18	1·40738	42
17	1·40780	42

ISOBUTYL BUTYRATE.

Bp = 154°·5–155°

T.	*n*.	diff.
20	1·40443	
19	1·40485	·00042
18	1·40527	42
17	1·40570	43
16	1·40612	42
15	1·40654	42

AMYL BUTYRATE.

Bp = 178°–178°·5

T.	*n*.	diff.
22	1·41010	
21	1·41052	·00042
20	1·41094	42
19	1·41135	41
18	1·41176	41
17	1·41217	41

METHYL ISOBUTYRATE.

Bp = 89°·8–90°

T.	*n*.	diff.
26	1·38082	
25	1·38136	·00054
24	1·38190	54
23	1·38243	53
22	1·38296	53
21	1·38348	52
20	1·38399	51

ETHYL ISOBUTYRATE.

Bp = 107°–107°·3

T.	*n*.	diff.
25	1·38537	
24	1·38589	·00052
23	1·38641	52
22	1·38693	52
21	1·38745	52
20	1·38797	52

PROPYL ISOBUTYRATE.

Bp = 130°·5–131°

T.	*n*.	diff.
25	1·39369	
24	1·39414	·00045
23	1·39459	45
22	1·39504	45
21	1·39549	45
20	1·39593	44
19	1·39637	44

ISOBUTYL ISOBUTYRATE.

Bp = 144°–145°

T.	*n*.	diff.
25	1·39775	
24	1·39819	·00044
23	1·39863	44
22	1·39906	43
21	1·39949	43
20	1·39992	43
19	1·40034	42

AMYL ISOBUTYRATE.

Bp = 166°–166°·5

T.	*n*.	diff.
25	1·40548	
24	1·40591	·00043
23	1·40634	43
22	1·40676	42
21	1·40718	42
20	1·40759	41
19	1·40800	41
18	1·40841	41

PROPYL VALERATE.

Bp = 155°·5–156°

T.	*n*.	diff.
24	1·40182	
23	1·40229	·00047
22	1·40275	46
21	1·40321	46
20	1·40366	45
19	1·40411	45
18	1·40455	44

ISOBUTYL VALERATE.

Bp = 169°–169°·4

T.	*n*	diff.
25	1·40393	
24	1·40441	·00048
23	1·40489	48
22	1·40536	47
21	1·40583	47
20	1·40630	47

From the above table it is seen, as has already been shown by Landolt and others, that the increase in n for one degree C. is in the mean about ·00045. As a rule this difference is not constant, but increases with the temperature; in a few cases, however, as for instance ethyl isobutyrate and isobutyl butyrate there are no second differences. Although the differences vary from ·00041 to ·00059, they seem quite irregular, and it is not easy to connect them with any chemical property of the bodies in question, and still more difficult is it to account for the appearance of the second differences in some cases and in others not. But I shall not attempt a further explanation of these points here.

Of the above-named ethers the refractive indices of propyl acetate alone have been determined, as far as I am aware. Brühl gives for this for a sample boiling between 99°–101° the index $n_D=1{\cdot}38438$ at 20°, and for another portion boiling from 97°–99° $n_D=1{\cdot}38360$. It will be noticed that the first of these values corresponds very closely with that obtained by me. Indeed the agreement is better than one might expect, when the great liability of the ether to dissociation is taken into consideration. Brühl mentions this fact, and I have reason to believe that the sample used by me had likewise been slightly decomposed by the fractional distillation.

In order to show the results obtained above, in their most general aspect, as well as for the purpose of better comparison with the work of others, I have arranged them in a more complete form below. In the columns headed d are contained the densities of the substances for each degree of temperature, calculated as explained at the outset. Under n are given the refractive indices to four places, the somewhat uncertain fifth place being omitted. Under $\frac{n-1}{d}$ is given the "specific refractive energy," and under $M\left(\frac{n-1}{d}\right)$ the "molecular refractive energy" for each compound at the various temperatures. M represents the molecular weight of the ether in question. I use these terms in the sense in which they have been employed by Dale & Gladstone and Landolt, and they need no further explanation. Propyl acetate I here omit, as I do not know the variations in its density with the temperature.

The quotients $\frac{n-1}{d}$ are on the whole quite satisfactory, although the fourth decimal places are not always the same. Some seem constant with the temperature, two increase, while the others are seen to decrease. The same irregularity has been already noticed by Landolt and Wüllner,* yet it still remains to be explained. In the above ethers it will be noticed

Methyl formate.

$M = 60$ $d_0 = \cdot99840$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
15	·9767	1·3460	·3543	21·26
16	·9753	1·3456	·3544	21·26
17	·9738	1·3452	·3545	21·27
18	·9723	1·3448	·3546	21·28
19	·9708	1·3443	·3547	21·28
20	·9694	1·3438	·3547	21·28

Propyl formate.

$M = 88$ $d_0 = \cdot91838$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
17	·8996	1·3790	·4213	37·07
18	·8985	1·3785	·4213	37·07
19	·8974	1·3780	·4212	37·07
20	·8962	1·3775	·4212	37·07
21	·8951	1·3770	·4212	37·07
22	·8940	1·3765	·4211	37·06
23	·8928	1·3760	·4212	37·07

Isobutyl formate.

$M = 102$ $d_0 = \cdot88543$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
16	·8697	1·3894	·4477	45·67
17	·8687	1·3889	·4477	45·67
18	·8677	1·3884	·4476	45·66
19	·8667	1·3879	·4476	45·66
20	·8657	1·3874	·4475	45·64
21	·8647	1·3869	·4474	45·64
22	·8637	1·3864	·4474	45·64

Methyl propionate.

$M = 88$ $d_0 = \cdot93725$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
15	·9277	1·3803	·4099	36·07
16	·9271	1·3798	·4097	36·05
17	·9265	1·3793	·4094	36·03
18	·9259	1·3788	·4091	36·00
19	·9252	1·3782	·4088	35·97
20	·9246	1·3776	·4084	35·94

Ethyl propionate.

$M = 102$ $d_0 = \cdot91238$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
15	·8959	1·3866	·4315	44·01
16	·8948	1·3862	·4316	44·02
17	·8937	1·3857	·4316	44·02
18	·8926	1·3852	·4316	44·02
19	·8915	1·3847	·4315	44·01
20	·8904	1·3842	·4315	44·01

Propyl propionate.

$M = 116$ $d_0 = \cdot90191$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
17	·8857	1·3950	·4460	51·73
18	·2848	1·3945	·4459	51·72
19	·8838	1·3940	·4458	51·72
20	·8828	1·3935	·4457	51·71
21	·8818	1·3930	·4457	51·70
22	·8809	1·3925	·4456	51·69
23	·8799	1·3920	·4455	51·68

Isobutyl propionate.

$M = 130$ $d_0 = \cdot88759$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
16	·8732	1·3992	·4572	59·43
17	·8722	1·3988	·4572	59·43
18	·8713	1·3984	·4572	59·43
19	·8704	1·3979	·4571	59·42
20	·8694	1·3975	·4572	59·43

Amyl propionate.

$M = 144$ $d_0 = \cdot88767$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
17	·8729	1·4078	·4672	67·27
18	·8721	1·4074	·4671	67·27
19	·8712	1·4070	·4672	67·27
20	·8703	1·4065	·4671	67·27
21	·8694	1·4061	·4671	67·27
22	·8685	1·4057	·4671	67·27
23	·8676	1·4052	·4671	67·27

Isobutyl butyrate.

$M = 144$ $d_0 = \cdot88178$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
15	·8674	1·4065	·4686	67·49
16	·8665	1·4061	·4687	67·49
17	·8655	1·4057	·4688	67·50
18	·8645	1·4053	·4688	67·50
19	·8636	1·4049	·4689	67·52
20	·8627	1·4045	·4689	67·52

Amyl butyrate.

$M = 158$ $d_0 = \cdot88231$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
17	·8673	1·4122	·4753	75·10
18	·8664	1·4118	·4753	75·10
19	·8655	1·4114	·4753	75·10
20	·8646	1·4110	·4754	75·11
21	·8637	1·4105	·4753	75·10
22	·8628	1·4101	·4753	75·10

Methyl isobutyrate.

$M = 102$ $d_0 = \cdot91118$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
20	·8893	1·3840	·4318	44·04
21	·8882	1·3835	·4318	44·04
22	·8871	1·3830	·4317	44·03
23	·8860	1·3824	·4316	44·02
24	·8849	1·3819	·4316	44·02
25	·8838	1·3814	·4315	44·01
26	·8827	1·3808	·4314	44·00

Ethyl isobutyrate.

$M = 116$ $d_0 = \cdot89037$

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
20	·8697	1·3880	·4461	51·75
21	·8686	1·3875	·4461	51·75
22	·8676	1·3869	·4460	51·73
23	·8665	1·3864	·4459	51·73
24	·8655	1·3859	·4459	51·72
25	·8644	1·3854	·4459	51·72

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
	Propyl isobutyrate.			
	$M = 130$ $d_0 = \cdot89299$			
19	·8748	1·3964	·4531	58·90
20	·8738	1·3959	·4531	58·90
21	·8728	1·3955	·4531	58·90
22	·8719	1·3950	·4530	58·89
23	·8709	1·3946	·4531	58·90
24	·8699	1·3941	·4530	58·89
25	·8690	1·3937	·4531	58·90
	Isobutyl isobutyrate.			
	$M = 144$ $d_0 = \cdot87496$			
19	·8584	1·4003	·4663	67·15
20	·8575	1·3999	·4664	67·16
21	·8566	1·3995	·4664	67·16
22	·8557	1·3991	·4664	67·16
23	·8548	1·3986	·4663	67·15
24	·8539	1·3982	·4663	67·15
25	·8530	1·3978	·4663	67·15
	Isobutyl valerate.			
	$M = 158$ $d_0 = \cdot87360$			
20	·8558	1·4063	·4748	75·01
21	·8549	1·4058	·4747	75·01
22	·8540	1·4054	·4747	75·00
23	·8531	1·4049	·4746	74·99
24	·8522	1·4044	·4745	74·98
25	·8513	1·4039	·4745	74·98

T	d	n	$\frac{n-1}{d}$	$M\left(\frac{n-1}{d}\right)$
	Propyl valerate.			
	$M = 144$ $d_0 = \cdot88092$			
18	·8652	1·4046	·4676	67·34
19	·8643	1·4041	·4676	67·33
20	·8634	1·4036	·4675	67·32
21	·8626	1·4032	·4674	67·31
22	·8617	1·4028	·4674	67·31
23	·8608	1·4023	·4674	67·30
24	·8599	1·4018	·4673	67·29
	Amyl isobutyrate.			
	$M = 158$ $d_0 = \cdot87597$			
18	·8598	1·4084	·4750	75·05
19	·8589	1·4080	·4750	75·05
20	·8580	1·4076	·4751	75·06
21	·8571	1·4072	·4751	75·07
22	·8562	1·4068	·4751	75·07
23	·8553	1·4063	·4750	75·06
24	·8544	1·4059	·4751	75·06
25	·8535	1·4055	·4751	75·07

that the constancy of $\frac{n-1}{d}$ is attained in eight cases, while in an equally great number it is not. An attempt to connect this peculiarity with others of the same bodies has not been successful.

An opportunity is afforded by the above experiments of comparing the physical characteristics of some of the butyrates and isobutyrates. The constants for methyl and ethyl butyrate are taken from Landolt's paper,† n_D being computed by means of the formula of Cauchy,

$$n_D = A + \frac{B}{\lambda^2_D}$$

in which A is the coefficient of refraction, and B that of dispersion. For the wave length of the line D, I have used the mean value given by Wüllner,‡ expressed in ten-thousandths of a millimeter, $\lambda_D = 5·893$.

From Landolt I take

Methyl butyrate	A = 1·37879	B = 0·35077
Ethyl butyrate	A = 1·38580	B = 0·35310

* Lehrbuch d. Experimentalphysik, vol. ii, p. 150.
† Pogg., cxxii, 545, where the values for A and B are given.
‡ Lehrbuch, etc., vol. ii, p. 136.

Making the necessary calculations I find the values as in the following table:

	Bp	d_{20}	n_{20}
Methyl butyrate	103–104°	·8976	1·3889
Methyl isobutyrate	90°	·8893	1·3840
Ethyl butyrate	114°	·8906	1·3960
Ethyl isobutyrate	107°	·8697	1·3880
Isobutyl butyrate	155°	·8627	1·4045
Isobutyl isobutyrate	144–145°	·8575	1·3999
Amyl butyrate	178°	·8646	1·4110
Amyl isobutyrate	166°	·8580	1·4076

As might be expected, the constants in the case of the iso compounds are in every instance lower than in those of the corresponding normals. Here as in several compounds examined by Brühl, the characteristic differences of ethers of normal and iso acids are seen to extend to their action on light.

It will not be without interest to find what values for the atomic refractive power can be deduced from the above observations. For this purpose I have grouped the ethers as in the following table. Arranging the isomers together, there are seven groups with different molecular weights, and for the molecular refraction of each I have placed the mean value of those of the several members of each group.

		$M\left(\frac{n-1}{d}\right)$	diff. for CH_2
Methyl formate	$C_2H_4O_2$	21·28	
Propyl formate / Methyl propionate	$C_4H_8O_2$	36·57	7·65
Ethyl propionate / Isobutyl formate / Methyl isobutyrate	$C_5H_{10}O_2$	44·56	7·99
Propyl propionate / Ethyl isobutyrate	$C_6H_{12}O_2$	51·72	7·16
Isobutyl propionate / Propyl isobutyrate	$C_7H_{14}O_2$	59·16	7·44
Amyl propionate / Isobutyl butyrate / Isobutyl isobutyrate / Propyl valerate	$C_8H_{16}O_2$	67·32	8·16
Amyl butyrate / Amyl isobutyrate / Isobutyl valerate	$C_9H_{18}O_2$	75·06	7·74

Mean diff. for $CH_2 = 7·69$.

It thus appears that the differences for CH_2 from group to group are not quite constant, but the variations are not greater than one might expect when the character of the compounds is taken into consideration. The average of the differences gives for the refractive power of CH_2 7·69. Substituting this in the different groups, we find for O_2 the refractive powers 5·90, 5·81, 6·11, 5·58, 5·33, 5·80 and 5·85. Of course it is not intended that these numbers represent the atomic refraction in

any particular groups. They are simply mean values obtained by combining the numbers M $\left(\frac{n-1}{d}\right)$ of the last table in a certain way. From other combinations it is plain that slightly different values would be obtained. The average of the results just given makes 5·77 the refractive power of O_2, that is of one linking and one saturating O as shown by Brühl. It will be seen that these values do not differ greatly from the mean refractive equivalents as given by Landolt—i. e., 7·60 for CH_2 and 3·00 for O, which it must be remembered were calculated from numbers differing as widely perhaps as the above. Whether these variations depend for their explanation on the possible impurity of the liquids examined, or whether they are to a greater extent due to peculiarities of each individual compound, is as yet not quite plain. It seems probable, however, in view of all that has been thus far done on the subject, that the latter is the more plausible supposition. But it is only by refined and extended investigations of various physical properties and correlation of the results thus obtained, that the complete solution of the problem may be expected. For this purpose, I had wished to make use of some of the results obtained by Pribram and Handl on the transpiration of liquids (Wien. Sitzungsbr. 80), but unfortunately I was unable to obtain this journal.

There are many other interesting peculiarities of these ethers which might be mentioned, but their discussion belongs more properly to an investigation soon to be expected (or perhaps recently published), from Herrn Emil Elsässer, to whom, as was mentioned, I am indebted for the data from which I calculated the densities of the liquids corresponding to the different temperatures. To Professor Meyer I would also express my sincere thanks for assistance, without which the completion of the above experiments would not have been possible.

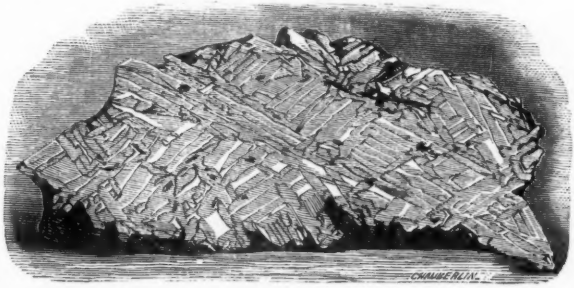
Wesleyan University, February, 1881.

ART. XXXIV.—*On the Whitfield County, Georgia, Meteoric Iron;* by W. EARL HIDDEN.

THIS iron was discovered in 1877 on a farm about twenty miles northeast of Dalton, Georgia, near the Tennessee and North Carolina State lines, a region which it will be remembered is remarkable for the number of meteorites it has afforded. As has happened in similar cases the specimen was locally considered to be *native iron* and was preserved as such until Dr. Geo. B. Little, then State Geologist of Georgia, visited the region in 1878, and recognizing its real nature procured it

for the State Museum at Atlanta. The writer saw it there in August, 1879, and with the consent of Dr. Little had a small piece planed off, an engraving of which is here given (exact natural size).

In its complete condition this meteorite is said to have weighed 13 lbs. Its present weight is $9\frac{3}{4}$ lbs. Dr. Little informs me that one end of it became detached on its journey to Atlanta, which piece he presented to the college at Athens, Ga. The mass remaining is thin oblong in shape, and much resembles a very rusty mass of ordinary iron. It is about ten inches long and five inches wide and varies in thickness from an inch to an inch and a half. Its surface is very irregular and has many jagged points. Only a preliminary analysis has been made on the piece in my possession; this has showed it to be not unusual in its composition; chloride of iron is largely present, its deliquescence was observed in many spots on the mass. The Widmannstätten figures are remarkably well shown on this iron, as the accompanying engraving proves. (This engraving was made from a photograph taken direct from the iron: its angles and measurements are therefore correct.)



Dr. Little informed me that this iron had not been, as yet, described, and accorded me the privilege of making public this account of its history. The cabinet of minerals, of which this meteorite forms a part, has been packed up in boxes and stowed away in the cellar of the Department of Agriculture building in Atlanta, and it is reasonable to suppose that this interesting mass of meteoric iron will sooner or later disappear through decomposition and oxidation; it seems right therefore that some record should be made in this Journal of its history and final location.

Note.—In a recent letter from Dr. A. Brezina of Vienna, I learn that he received a small piece of this meteorite in Nov., 1879, and that he published a notice about it in the "Anzeiger der K. K. Akad. der Wiss., Wien." I have not seen his note. The data of this article were personally obtained by the writer in August, 1879.

ART. XXXV.—*The Basin of the Gulf of Mexico.* A communication to the National Academy of Sciences made Nov. 18, 1880, by authority of C. P. PATTERSON, Supt. U. S. Coast and Geodetic Survey, by J. E. HILGARD, M.N.A.S. With a Map of the Gulf (Plate IX).

AT the meeting of the National Academy of Sciences in New York, Nov. 18, 1880, Mr. J. E. Hilgard presented, on the part of Hon. C. P. Patterson, Superintendent of the U. S. Coast and Geodetic Survey, a model of the Gulf of Mexico, constructed from the numerous soundings taken in the progress of that work. The accompanying plate (IX) is a reduced plan of the model, the full size of which is 24×32 inches, being on a horizontal scale of 1 : 2,400,000, and on vertical scale of 1 inch : 1000 fathoms; making the proportion of horizontal to vertical scale 1 : 33. The plan shows the horizontal curves for every 500 fathoms of depth, as well as the curves of 100 and 10 fathoms. The same curves are delineated on the model, the forms of which are shaped in conformity with all the detail obtained from the soundings.

The number of soundings taken within the depth of 100 fathoms is very large, varying according to the configuration and importance of the locality. Beyond 100 fathoms, where the work pertains rather to physical exploration than to navigation, 1,055 soundings have been obtained, which is an average of ten to a rectangle comprised within a degree of latitude and longitude; of these, 355 are in depths greater than 1000 fathoms.

The object of this communication being merely to give a general description of the orographic features of the basin of this great inland sea—the American Mediterranean—it is only necessary to mention here that in connection with the soundings, temperatures were observed at various depths and the organic life was explored by means of dredges. The results of these physical and biological explorations are in the ablest hands for discussion and interpretation but are not yet ready for publication. It is therefore only necessary to state here, as a general fact, that below the depth of about 800 fathoms the temperature is everywhere found to be between 39° and 40° F.

Before reviewing the structural features of the Gulf-basin which the model reveals in a most striking manner, it is proper to recite here briefly the history of the exploration of the Gulf by the United States Coast Survey. The surveys of the shores and soundings of the approaches were begun as long ago as 1846 under the superintendency of Professor A. D. Bache and were continued until the outbreak of the Civil War.

From the earliest date of his work, Bache had in view the exploration of the Gulf Stream and its attendant physical facts in addition to the surveys requisite for navigation. As early as 1845 temperatures were observed over sections across the Gulf Stream on the Atlantic part of our coast which observations were systematically extended southward. In 1850, Professor L. Agassiz examined the structure of the Florida Reefs in connection with the Coast Survey hydrographic party under the command of Lieut., now Admiral John Rodgers, U. S. N. In 1855, a cross section from Cape Florida to the Bahama Banks, observed by Lieutenant Craven, U. S. N., developed the fact that the Strait is a comparatively shallow channel, a greatest depth of 370 fathoms only being found. In 1860, Lieutenant Murray, U. S. N., found a greatest depth of 344 fathoms in a section across from Indian River, not far from the former line. Some deep soundings in the Gulf reaching nearly 1200 fathoms were obtained by Lieut. Sands, U. S. N., about the same time.

When after the close of the Civil War the Coast Survey resumed its former activity, under the administration of Professor Benjamin Peirce, soundings across the Florida and Yucatan Channels were obtained by Master R. Platt, U. S. N., accompanied by a dredging party under the direction of the late L. F. Pourtales.

It was not, however, until the present Superintendent of the Coast Survey, C. P. Patterson, LL.D., organized a systematic exploration of the whole Gulf, that its character became rightly understood. This exploration was begun in 1872 by Commander Howell, U. S. N., on the west coast of Florida in comparatively shallow water and was continued and brought to a successful conclusion by Commander Sigsbee, U. S. N. (1875–78) in the Coast Survey Steamer Blake, accompanied by Professor A. Agassiz, who had charge of the biological explorations.

The methods of sounding and obtaining temperatures at great depths as well as those of dredging have been described in the Coast Survey Reports for several years, and more especially in a work recently written by Commander Sigsbee, U. S. N., and published by the U. S. Coast Survey. It will suffice to mention here that the method of sounding employed was that of using a fine steel wire, indicated by Sir Wm. Thomson, with the mechanical appliances perfected by Commanders Belknap and Sigsbee, of the U. S. Navy.

Turning now to our model or map we perceive that the basin of the Gulf of Mexico is an oval connected with the general ocean circulation by two outlets, the Yucatan Channel and the Florida Straits.

The area of the entire Gulf, cutting it off by a line from Cape Florida to Havana, is 595,000 square miles. Supposing the

depth of the Gulf to be reduced by 100 fathoms, a surface would be laid bare amounting to 208,000 square miles, or rather more than one-third of the whole area. The distance of the 100 fathom line from the coast is about six miles near Cape Florida; 120 miles along the west coast of Florida; at the South Pass of the Mississippi it is only 10 miles; opposite the Louisiana and Texas boundary it increases to 130 miles; at Vera Cruz it is 15 miles, and the Yucatan Banks have about the same width as the Florida Banks.

The following table shows the areas covered by the trough of the Gulf to the depths stated:

Depth.	Area.	Differences.
2,000 fathoms	55,000 square miles	
1,500 fathoms	187,000 square miles	132,000
1,000 fathoms	260,000 square miles	73,000
500 fathoms	326,000 square miles	66,000
100 fathoms	387,000 square miles	61,000
Coast line	595,000 square miles	208,000

This table shows that the greatest slopes occur between the depths of 100 and 1,500 fathoms. The maximum depth reached is at the foot of the Yucatan Banks—2,119 fathoms. From the 1,500 fathom line on the northern side of the Gulf to the deepest water close to Yucatan Banks, say to the depth of 2,000 fathoms, is a distance of 200 miles, which gives a slope of five-ninths to 200, and may be considered practically as a plane surface.

The large submarine plateau below the depth of 12,000 feet has received the name of the "Sigsbee Deep," in honor of its discoverer.

The Yucatan channel with a greatest depth of 1,164 fathoms has a cross section of 110 square miles, while the strait of Florida in its shallowest part opposite Jupiter Inlet, with a depth of 344 fathoms, has a cross section of only 11 square miles.

A view of the model reveals at once some important facts which a study of the plan only conveys imperfectly to the mind, and which were unsuspected before this great exploration was completed: Thus the distance between the visible coast lines of the northeastern point of Yucatan and the west coast of the Florida Peninsula is 460 miles, while the distance between the submerged contours of 500 fathoms is only 190 miles; between the contours of 1,000 fathoms only 90 miles. These facts at once characterize the Gulf of Mexico as a Mediterranean Sea.

The most striking features displayed by the model are the following:

1. The great distance to which the general slope of the continent extends below the present sea level before steeper

slopes are reached. The 100 fathom curve represents very closely the general continental line; the *massifs* of the peninsulas of Florida and Yucatan have more than twice their present apparent width. As previously stated, one-third of the whole area of the Gulf has a depth of less than 100 fathoms.

2. Very steep slopes lead from this submerged plateau to an area of 55,000 square miles, as great as that of the State of Georgia, at the great depth of over 12,000 feet. There are three ranges on the Florida and Yucatan slopes extending in the aggregate to more than to 600 miles, along which the descent between 500 to 1,500 fathoms, or 6,000 feet, is within a breadth of from six to fifteen miles. No such steep slopes and correspondingly elevated plateaus appear to exist on the unsubmerged surface of the earth. The suggestion occurs that while the latter have suffered atmospheric erosion, the submerged surfaces have not sensibly changed from the positions determined by the mechanical shaping of the earth's crust.

3. The far protrusion of the Mississippi delta toward the deep water of the Gulf seems to give evidence to the engineer of the probably permanent success of the Mississippi Jetties, as delivering the silt of the river into water of so great depth, that but few extensions will ever become necessary. In connection with the same feature, the strong indentation to the westward of the present mouths of the Mississippi, indicating the probable site of the original fracture between the two slopes of the Mississippi Valley deserves attention.

4. In regard to the problem of general ocean circulation in connection with the Gulf Stream, the most important feature is the shallowness and small cross section of the Strait of Florida between the Peninsula and Bahama Banks, having at the shallowest part a cross section of 11 square miles only with a greatest depth of 344 fathoms. From observations reported elsewhere in the Coast Survey Reports, the average northwardly current of the warm water through this strait is probably not greater than two miles per hour, certainly not more than 2½ miles. It is evident at once that the warm water which so greatly modifies the climate of the western coasts of Europe cannot all be supplied by the flow through this small channel. The concentration of the warm surface current from the Gulf of Mexico gives to this vein of the general circulation of the Atlantic Ocean a marked velocity which is very perceptible to the navigator, and has given its name of "Gulf Stream" to the whole system of northeasterly surface flow in the Atlantic Ocean. In view of the foregoing facts it appears to be necessary to assume now that the so-called Gulf Stream is largely reinforced by a general northerly current from the outside of the West Indian Islands.

ART. XXXVI.—*On the Geology of Florida;* by EUGENE A. SMITH, of the University of Alabama. With a Map.

DURING an excursion into Florida, made last summer for the purpose of collecting data for the Cotton Culture Report of the Tenth Census, I made incidentally some notes on the geological formations of that State, which, with the kind consent of the Superintendent, are now made public.

The literature of this subject is extremely meagre, and I propose first to give a concise account of the published observations of my predecessors in this field, so far as I have been able to consult them.

In this Journal, I, xxxv, pages 47 et seq., are found some "Cursory Remarks upon East Florida in 1838, by Maj. Henry Whiting, U. S. Army." This paper is chiefly descriptive of the topography, natural productions and climate of the country, yet it contains some observations upon the geology. The author states that the "rocks found *in situ* are all calcareous, though siliceous bowlders of small size are occasionally seen, and nodules of hornstone are here and there mingled with the limestone, which elicit sparks, and are sometimes used by the Indians for flints." ..... "The coast, as far as Cape Florida, is alluvial, a seeming mass of comminuted shells, resting on a rocky formation, composed also of shells, more or less broken and abraded. From Cape Florida, the formation is mostly coralline, the Keys being of that character." ..... "As high as Indian River Inlet, the beach is still formed of shells, ... mingled with some sand; while about Cape Canaveral the sand predominates, until shelly fragments almost disappear to the naked eye. Still it seems probable that the whole beach is of a calcareous character."

The author then describes the "coquina" rock quarries of St. Augustine, adding some conjectures as to the mode of formation of this singular rock, which he states is generally considered as of recent formation, and that causes are still operating to produce it. This conjecture, while apparently plausible, wants, in his opinion, the support of deeper investigation into the character and force of these causes.

He speaks of the shell formations of the Upper St. Johns, which are made up chiefly of a species of Helix—the soil at Volusia and Fort Mellon consists half of shells, generally perfect in shape but occasionally slightly broken or abraded.

"On Black Creek, west of the St. Johns, a porous, rotten limestone appears, and this is said to be characteristic of the rock formations throughout the western part of the peninsula. Hence the many 'surth-holes' ..... which appear in these

regions, and the disappearance of streams for many miles beneath the surface of the earth, while others come forth in all their fullness at once."

He also speaks of the large limestone springs, frequently impregnated with sulphuretted hydrogen.

In volume i of the 2d series of this Journal, page 38, we find "Some Facts respecting the Geology of Tampa Bay, by John H. Allen, Lieut. of Artillery in U. S. Army."

This author describes a limestone occurring at Fort Brooke, at the head of Tampa Bay, as hard, white, with an earthy texture, and apparently formed of decomposed and comminuted shells; in some places it is soft and friable, very much resembling chalk. He states further, that he has noticed this rock at points more than one hundred and fifty miles distant from each other, and presenting the same lithological characters; it constitutes the bottom of the many ponds and lakes in the interior, and he has been informed that its white and jagged surface can be seen throughout the whole extent of the Everglades. He mentions fossils contained in the rock, univalves, bivalves and echini; and he ascribes the great fertility of some of the sandy soils of the territory to the loose marl disseminated through it.

According to the author, there is another rock probably dipping beneath the limestone—a dark bluish, siliceous rock, of a compact texture, somewhat vesicular, the vesicles containing minute crystals of quartz. This rock was noticed at the falls of Hillsboro River, nine miles from its mouth. Bowlders of it were also seen at several places in the interior. Large sulphur springs with clear pellucid water are mentioned as occurring in the vicinity of Hillsboro River and other streams flowing into Tampa Bay.

Near Tampa Bay are beds of marl which differ materially in their composition and organic contents; they evidently belong to different geological periods. One of the most ancient and interesting of these beds occurs two miles west of Fort Brooke, and it is well known as furnishing the beautiful fossils petrified with wine-colored chalcedony. Other beds of marl, apparently of much more recent origin, extend along the shore at Fort Brooke.

Farther south, near the mouth of the Manatee River, is an extensive bank of shells, ten feet or more in thickness, composed almost wholly of large unbroken univalves belonging principally to a species of *Pyrula*, without any admixture of earth. Although he observed many fragments of Indian pottery in these shell heaps, the immense quantity of the shells precludes the idea that they have been accumulated by the aborigines of the country. In this paper the author makes a

clear distinction between the marl beds near the shore and the more ancient marls, and limestones occurring farther inland, although he does not undertake to decide upon the geological age of either.

His remarks upon the distribution of the more ancient limestone in the interior, where it forms "the bottoms of the many ponds and lakes," are particularly interesting, in the light of my recent observations.

We come next to an important paper by T. A. Conrad: "Observations on the Geology of a part of East Florida, &c."* In this, the author describes certain Post-Pliocene deposits on the St. Johns River and at Tampa Bay, occurring ten or fifteen feet above high tide; proving a considerable elevation of the whole Florida peninsula in the Post-Pliocene period, a movement which clearly raised all the Florida Keys above water. The greater part of the paper is devoted to a description of the Keys, with notices of the shells occurring on them and in the neighboring waters. At Tampa Bay and southward along the shore, he notices the Post-Pliocene deposits, but calls attention also to an underlying limestone occurring at Fort Brooke and as far inland as the Falls of Hillsboro River. This limestone he refers to an upper division of the Eocene. The same rock occurs, he says, a few miles up the Manatee River. Closer examination of the casts and shells from Tampa, brings the author to the following conclusions, viz., that the Nummulite limestone of St. Stephens and of Clarke County, Ala., and the fossiliferous bluff at Claiborne, are to be classed as Lower Eocene, while the limestone of Savannah River, containing two recent shells, he proposes to call Upper Eocene, and very probably the prevalent limestone of Florida will be included in this division."† This rock, he states, extends throughout the peninsula, as far south as Tampa Bay; and both the eastern and western shores are covered with a Pleistocene formation of recent species of shells, and remains of mammalia. The elevation of East Florida above the sea level is so inconsiderable that all or nearly all of it must have been submerged at the time the Post Pliocene species were existing, and therefore its elevation was contemporaneous with that of the Keys, which line its eastern, western and southern shores."‡

We have here the first definite attempt at the determination of the age of the Florida limestone.

In volume ii of this Journal, 2d series, p. 399, Conrad gives "Descriptions of new species of Organic remains from the Upper Eocene Limestone of Tampa Bay." In this article he

* This Journal, II, ii, 36 et seq.

† In more recent papers by Conrad these views are slightly modified.

‡ In this connection, see table of altitudes appended to the present article, and Dr. Burnett's letter below.

describes *Bulimus Floridanus*, *Bulla petrosa*, *Nummulites Floridana*, *Cristellaria rotella*, *Venus penita*, *Venus Floridana*, *Nucula tellinula*, *Cytherea Floridana* and *Balanus humilis*.

In this Journal, 2d series, vol. x, p. 282, Professor J. W. Bailey notes the discovery by him of an Infusorial stratum, between the mouth of Hillsboro River and Ballast Point. He is doubtful about the geological position of this bed, but states that it is associated with strata containing fossils which appear to belong to the epoch of the Eocene Tertiary.

During the summer of 1850, Professor M. Tuomey, of the University of Alabama, paid a short visit to the coast of Florida, with the view of comparing the recent deposits there with the white limestone (St. Stephens, etc.,) of Alabama, and in this Journal, 2d series, vol. xi, pp. 390 et seq., he published "A notice of the Geology of the Florida Keys, and of the Southern Coast of Florida." The author describes the limestone of the Keys—in which the fossils are all identical with the shells living in the surrounding waters—and points out the agency of the Mangrove tree in the formation of islands between the mainland and the Keys. At Tampa Bay he confirms the observation of Conrad respecting the Tertiary age of limestone there, which he says extends doubtless to Charlotte Harbor.

The limestone which underlies the Everglades he states to be similar in every respect to that at the mouth of the Miami River, which, in turn, is of the same age as the rocks examined at Key West and elsewhere inside the reef. He calls attention to the fact that an elevation of the Keys, of about ten to twenty feet, would form a ridge similar to that surrounding the Everglades, shutting out the sea from the space, at present between the reef and the mainland, thus producing a second "Everglade," differing from the present only in its greater comparative length.

In the same volume, p. 86, Professor J. W. Bailey publishes a notice of "Silicified Polythalamia in Florida," in which he speaks of large masses possessing all the mineralogical characters of flint, as occurring in the white Orbitulite limestone which is common throughout the portion of Florida between Tampa and Pilatka. The flint was collected about forty miles west of Pilatka, and upon examination of thin sections by the microscope, *Orbitulina*, *Nummulina*, *Rotalia*, *Textilaria*, etc., were recognized in numerous specimens.

In a letter to Professor Dana, Dr. W. I. Burnett (this Journal, II, vol. xvii, p. 407) calls attention to the circumstance that the peninsula of Florida is by no means so flat as is generally supposed, for surveys made by Gen. Barnard establish the fact that there is an elevated ridge in places 237½ feet

above low tide in the Atlantic, extending slopingly from north to south, and terminating at a line drawn from Cape Canaveral to Tampa Bay. At points only fifteen or twenty miles west of the St. Johns River, there are elevations at least of 100 to 150 feet. The author believes that all Florida is of comparatively recent age, except the elevated ridge spoken of above, but he does not express any opinion as to the age of this ridge. He endorses Professor Agassiz's conclusion respecting the recent origin of the Everglades.

In the winter of 1851, Professor Joseph LeConte, in company with Professor Agassiz, visited and examined the Keys and reefs of Florida, and the results of his observations are recorded in an article in this Journal, II, vol. xxiii, pp. 46 et seq., entitled, "On the Agency of the Gulf Stream in the Formation of the Peninsula and Keys of Florida." The author states that until the time referred to (1851), nothing definite was known concerning the geology of Florida, but it was supposed to consist of a southward prolongation of the Eocene of Georgia and Alabama, and its shell limestone to bear some general resemblance to the white limestone of these States. But the observations of Professor Tuomey in 1850, and the more full and careful observations of Professor Agassiz during the following winter, brought to light the remarkable fact, that the Keys and the larger portion of the peninsula of Florida are of recent origin, and as far as could be examined, the work of corals still living in the vicinity, and still engaged in the work of extension. He then goes on to give his well-known theory of the agency of the Gulf Stream in forming the submarine banks upon which the reef-building corals could grow.

The author states that the eastern coast of Florida, from Lake George as far north as St. Augustine, is of recent coral formation similar to that of the southern coast and Keys; and supposing the statements of Conrad and Tuomey concerning the Eocene age of the limestone near Tampa to be correct, though *still problematical* in his opinion, he thinks that all that portion of the peninsula lying south of a line connecting St. Augustine with Tampa Bay, is almost certainly of coral origin and formed by the growth of successive reefs.

In vol. ii, art. 8, of the Smithsonian Contributions, Professor J. W. Bailey publishes his microscopical observations made in South Carolina, Georgia and Florida. This I have not been able to consult. The monograph of Professor Agassiz, also, I have not been able to see.

The last Geological Map of the United States, by Professors Hitchcock and Blake, accompanying the publication of the Ninth Census, represents the whole of Florida as alluvial.

From the preceding notes, it will be seen that while many

valuable observations on Florida geology have been recorded, yet the subject is still enveloped in obscurity, partly because of the isolated character of the earlier observations, and partly because of the failure of the later observers to give due weight to the statements of those preceding them.

I give now some notes of my own recent observations:

In the lower part of Geneva County, Ala., the Orbitoides limestone of Vicksburg age, is exposed in many places, and passing thence southward into Jackson County, Fla., the same rock is found underlying the whole county from Campbellton to Marianna, and thence eastward to Chattahoochee, and northeastward through Greenwood to the river. The Vicksburg formation in Mississippi, Alabama and Florida, is almost everywhere covered with superficial beds of pebbles and sand (Orange Sand or Stratified Drift), and of yellow or red loam (Hilgard's Yellow Loam). The sand is rarely absent, the pebbles are distributed in belts which follow more or less closely the valleys of the principal rivers; the loam, together with the great mass of *yellow* and *red* sand of Stratified Drift age, which it overlies, thins out rather abruptly along an irregular line, which in Alabama and Florida may be roughly drawn as follows: from the northern boundary of Escambia County, Ala., eastward and southward through the lower part of Covington, diagonally across Geneva, through the lower part of Henry County; whence it is deflected southeastward so as to include parts of Gadsden, Leon and Jefferson Counties in Florida, and thence eastward and northward through parts of Madison and Hamilton Counties into Georgia. North of this line the country is more or less hilly and broken, the mean level of the uplands being perhaps 250–300 feet above the main watercourses, while southward the country slopes away to the gulf in an almost unbroken plain, the inequalities of the surface being everywhere comparatively slight, with scarcely anything deserving the name of *hills*.* This sea-ward, or rather gulfward, slope is covered almost uniformly with sand, which has rarely the bright yellow and red colors of the Stratified Drift sand further north. The timber is almost as uniformly long-leaf pine, with sometimes an undergrowth of small oaks, but often only of wire-grass. Exceptions to this state of things are found in the so-called "hammocks," where the soil is of

* From Clinch and Chariton Counties in Georgia, through Baker, Bradford and Clay Counties in Florida and thence southward, runs the Trail Ridge, which is 210 feet above sea level, where crossed by the Fernandina and Cedar Key railroad. And further west there is a range of sand hills 120 feet above sea level, between Archer and Bronson stations; but in both cases the local inequalities of the surface are exceedingly small, so that even upon the summit of Trail Ridge it is difficult to realize that one is upon an elevated plain, and not in a low pine barren.

darker color from intermixture of marl or disintegrating limestone, and where varieties of oak and hickory replace partly or wholly the lonely pine.

In the hilly country above mentioned, rocks of Vicksburg age are exposed along the banks of streams, ravines, etc., and sometimes as outcrops upon level ground; but on the Gulf slope, these exposures are usually at the edges and bottoms of the large "boiling springs" or "blue springs" which are so numerous throughout this entire region, and so characteristic of the formation wherever it makes a level, flat country. Occasional outcrops through the sand covering are to be noticed, and some streams like the Suwannee River, flow in part of their courses through channels cut in this limestone.

Where the limestone is hidden completely over large areas by the prevailing sands, its presence below is indicated by the sink-holes, ponds and lakes, which more than any other single feature are characteristic of the Florida landscape.

These being all due to the same cause, viz., the formation of subterranean caverns and the sinking in of superincumbent strata, the same depression may at one time be a mere lime-sink, (or "prairie" as the larger sunken areas—destitute of trees and carpeted with a dense growth of "blanket" grass—are called) or subsequently, a pond or lake, by the collection of water in the depression. A good example in point is Payne's prairie near Gainesville, which for many years was a widely-known pasture ground, to which thousands of cattle were driven from long distances. A small creek flowed through this basin, disappearing near its northern edge into an underground channel. During the great storm of 1871 this outlet was closed, and the "prairie" has become a lake several miles wide and from fifteen to twenty feet deep. As a matter of course, these phenomena are not confined to any particular limestone, and the occurrence of a *Miocene* limestone forming the basin of Rock Spring in Orange County, is noted below; still, from specimens collected by me at points widely distant from each other, from the observations of others as quoted above, and from evidence derived from other sources, I am brought to the conclusion that almost the whole State of Florida, from the Perdido River on the west, eastward and southward, including the middle and western parts of the peninsula, certainly as far south as the latitude of Tampa Bay, and probably as far as the latitude of Charlotte Harbor, has for its underlying formation the white or Orbitoides limestone of Vicksburg age, the exceptions as yet known being the Post Pliocene or recent limestones forming the Keys and the immediate coasts along the western, southern and eastern shores, and isolated patches, if not a continuous belt of Miocene lime-

stone between the St. Johns River and the elevated table lands westward.

The following notes present proofs more or less conclusive of the statement above made:

1. *West Florida.*

The occurrence of Vicksburg limestone in Jackson County has already been noticed, and specimens of *Orbitoides Mantelli*, *Pecten Poulsoni*, and other characteristic fossils were collected *in situ* at several localities, e. g., a few miles southeast of Campbellton, at the Big Spring east of Marianna, etc., while the use of blocks of this stone in the construction of chimneys, through the eastern and northern portion of the county, attest its occurrence everywhere in those parts. In the region referred to, the limestone lies very near the surface, often outcropping over considerable areas, and to this circumstance is probably due the exceptional fertility of much of the soil of Jackson County.

Holmes Valley on the creek of same name in Washington County, another widely-known fertile tract of land, presents the same geological features as the portion of Jackson County just mentioned.

Westward, in Holmes, Walton, Santa Rosa and Escambia Counties, the surface is generally covered with sand, so that outcrops of rock are not numerous; but the great number of "boiling" springs, sink-holes, ponds and lakes, taken in connection with the distribution of the Orbitoides limestone in the adjacent counties of Alabama, make it almost certain that this rock underlies most of West Florida, down at least to the near vicinity of the Gulf coast.

2. *Middle and South Florida.*

In these portions of the State my observations have covered a larger extent of country and are correspondingly more conclusive as to their geological structure.

Near the village of Chattahoochee, the bluff of the Appalachicola River is formed in part by the Vicksburg limestone, which has here a tolerably thick covering of Stratified Drift, consisting of reddish and yellow sands with some small pebbles. The greater part of Gadsden County, as far east at least as Quincy, is a high level plateau with thick beds of Stratified Drift and Yellow Loam as surface materials. For this reason exposures of the underlying rock are not numerous, except toward the river, along the lower parts of the water courses. Liberty County was not visited, but from information obtained at Mount Pleasant, I feel very well convinced that the Vicksburg limestone makes its appearance along the river as far south as Rock Bluff.

Leon, Jefferson and Madison Counties are similarly covered with thick beds of Stratified Drift and Yellow Loam, and near the Georgia line the country is somewhat hilly. Going southward from Tallahassee, however, one descends from the elevated country, two miles from the town, to the low, flat pine woods which slope away gently toward the Gulf. Here, the usual feature of the Gulf slope are observed, viz: limesinks, ponds, lakes, boiling springs, and outcrops of limestone. Specimens of this rock collected about six miles from St. Marks, in Wakulla County, were submitted to Mr. Angelo Heilprin, and by him pronounced to be of Vicksburg age, *Orbitoides Mantelli* being prominent among the fossils.

In many places near the coast in Wakulla County, a very finely pulverized white marl is mingled with the sand, imparting to it a great degree of fertility; this is the "Gulf Hammock" land of which much has been written. From enquiries, and from the observations of Conrad and others, I learn that these "Hammocks" exist all along the coast from Wakulla, through Taylor, Lafayette, Levy and Hillsboro Counties to Tampa Bay. This marl is also of Vicksburg age where I have examined it, and from descriptions which I have had from various sources, it seems almost certain that the marls of the Gulf Hammocks in the other counties named, are of the same geological age. In Jefferson, Madison and Hamilton Counties, the Vicksburg limestone underlies the Stratified Drift everywhere, as may be seen in its outcrops along the banks of streams. In Suwannee and Columbia Counties the Vicksburg is still the underlying rock, the surface covering being here light colored sands chiefly—the yellow and reddish sands and loams of the adjoining counties westward, being usually absent. Specimens of the limestone with characteristic fossils have been collected in the vicinity of Live Oak, and an earthy limestone, the counterpart of some of the Vicksburg limestone, in which, however, no fossils were observed, was noticed by me near Lake City and thence out near to the Suwannee shoals on the river of same name. I am informed that the rock at the shoals is highly fossiliferous. At the time of my visit it was hidden by high water.

The Suwannee River, which has its head waters partly in Okefinokee Swamp in Georgia flows through most of its course in Florida, between banks of Vicksburg limestone, and several large sulphur and limestone springs break out through crevices in the rock along the river.

A bed of what I suppose is *lignite* has been found lower down the river; the exact locality I could not learn; but a large quantity was raised some years ago, and experiments, with unfavorable results, made with it in Tallahassee, to test its fitness as a material for the manufacture of illuminating gas.

Okefinokee Swamp, in Georgia and Florida, as may be seen from a map, is upon the water-shed between the Suwannee and St. Mary's Rivers; this ridge is prolonged southward and eastward as Trail Ridge, through Baker, Bradford and Clay Counties, and the elevation (whether by that name or some other) is continued, according to my own observations and those of others, nearly to the Everglades. Although observations are as yet wanting, to prove that the Okefinokee swamp reposes upon a bed of Vicksburg limestone, yet the occurrence of that rock along its southwestern and southern edges in Florida, as above mentioned, makes it very probable that such will be found to be the case, especially when we consider the fact that farther south along this ridge and particularly along its western slope in Alachua, Marion and Sumter Counties, the Orbitoides limestone is everywhere the underlying formation, sometimes hidden by overlying sands, but often outcropping over extensive areas.

The enumeration of a few localities from which characteristic fossils have been collected, will make more definite this general assertion. Orbitoides limestone is the prevailing, and I might say the only, rock in the vicinity of Gainesville, many of the chimneys and pillars of the houses there are built of it. The limestone is often a mass of shells and in places *O. Mantelli*, forms it to the almost total exclusion of every other species.

Payne's Prairie, south of Gainesville, already mentioned above, occupies a depression or sink in this limestone.

The observations of Professor J. W. Bailey quoted above, show that the same formation extends at least to within forty miles of Pilatka. Between Gainesville and Ocala in Marion County, the chimneys of the farm-houses reveal the character of the underlying rock. At Ocala, it outcrops in numerous localities, *Orbitoides Mantelli*, here as at Gainesville, often forming the entire rock. Silver Spring, six miles east of Ocala, occupies a basin in the same limestone. This is one of the largest of the very numerous sulphur springs of the peninsula. Steamers from the Ocklawaha come up into the spring where they can easily turn. The waters of the spring as well as of the stream—twenty feet or more in width, fifteen in depth, and eight miles in length, from the spring to the river,—are beautifully clear, the jagged edges of the limestone banks, the numerous fish, and even objects lying upon the bottom, being distinctly visible from the deck of a steamer.

Specimens of limestone from Silver Spring were found by Mr. Heilprin, to be composed of *O. Mantelli* Morton and *O. supera* Con., to the exclusion of other forms except polyzoa.

About Ocala, southward and southwestward, is a belt of

"hammock" land, where an earthy, partly disintegrated limestone mingles with the surface soil. Reference to tables of elevations appended below, will show that this hammock land, is sixty feet higher than the sandy plain of Ocala. My own observations in the interior confirm the statement of Conrad with reference to the Gulf Coast near Tampa that the Tertiary limestone is certain to be the substratum of all the "hammock" land.*

From Sumter County I have no specimens of the limestone, but from statements made by the inhabitants, there seems to be little if any doubt that the rock which outcrops in the western and southern parts of the county toward Tampa, is Vicksburg limestone. It is described to me as being in part a mass of shells, in part earthy and disintegrated, in part flinty, all well known characters of this formation in Florida, and its use in the construction of chimneys in that part of the county, is at least *suggestive* of its age.

We have thus traced the Vicksburg limestone, by its *actual outcrops*, from Jackson County in West Florida, through Middle Florida, into South Florida below Ocala in Marion Co. The observations of Conrad, Tuomey and others, prove its occurrence at Tampa and probably at Charlotte Harbor. That it underlies also the other counties of West Florida, and part of those south of Sumter nearly to the Everglades† is open to very little doubt, still we must draw a sharp line of distinction between what has *actually been proven* by personal observation, and what is only *an inference* from the facts observed, however strongly the inference may be supported by the facts.

In Orange County between Sanford and Lake Apopka, there are several large sulphur springs of the kind already mentioned, affording streams navigable by small steamers. Three of these, Hoosier Spring, Clay Spring and Rock Spring, all within eight or ten miles of the village of Apopka, were visited by me. They all come up through fissures in limestone. At the first two, at the time of my visit, the limestone was so deep under water, by reason of recent heavy rain storms, that it could not be closely examined. At Rock Spring, however, there is a bluff of limestone some ten feet in height, and from this I was able to collect a number of fossils. They were submitted to Mr. Heilprin who determined among them the following species: *Pecten Madisonius*, *Venus alveata*, ‡*Cardita granulata*, ‡*Carditamera arata*, *Mytiloconcha incurva*; doubt-

* This Journal, II, vol. ii, p. 43.

† From the distribution of the Vicksburg limestone in the lower part of the peninsula, I am strongly inclined to believe that it will be found on further examination, to underlie a part, at least of the Everglades.

‡ Also Pliocene.

ful were also *Cardium sublineatum* and *Oliva litterata*. This would make the limestone of Miocene age, as Mr. Heilprin states his belief that *no* Vicksburg species are associated with the shells enumerated.

I do not know that Miocene limestone has been observed elsewhere in the state, but it seems probable that it will, upon examination, be found either in isolated patches, or forming a continuous belt between the Post Pliocene deposits toward the east, and the elevated country westward, which has as a substratum the Vicksburg limestone.

My observations along the St. Johns River from Sanford to Jacksonville have added nothing to what has already been recorded, although corroborating the statements quoted above in the introduction.

Summary of Observations.

From the foregoing pages it will be seen that the earlier observers, Major Whiting in 1838, and Lieutenant Allen in 1846, mention the occurrence in the peninsula of a limestone *older* than that forming the coasts and keys: the latter author making the statement that it underlies even the Everglades. In 1846 also, Conrad determined definitely the age of the older limestone occurring at Tampa Bay, and expressed the opinion that the prevailing limestone of the peninsula would be found to be of the same age. In 1850, Tuomey confirmed Conrad's statement concerning the age of the rock at Tampa.

Up to this time it appears, as LeConte states, that it was the general opinion that the Florida peninsula was substantially a prolongation southward of the Eocene limestone of Georgia; but the researches of Agassiz and LeConte in bringing more prominently into view the recent character of the coasts and keys, and of the extreme southern end of the peninsula, together with the extension of the theory of the latter author, regarding the successive additions to the end of the peninsula, by coral formations, threw a shade of doubt, to say the least, over the observations of Conrad and others, which we now know to have been correct. The result has been, that since 1856 or 1857, a general impression has prevailed, that with the exception of the problematical Tertiary limestone at Tampa, the whole of Florida was of comparatively recent origin, and so it is laid down in the latest geological map.

In what precedes, I believe that I have established, beyond doubt, the correctness of the older views concerning the geological structure of the greater part of the peninsula, which views, so far as the published records show, were based either upon casual statements or conjectures of authors, except in the case of Tampa and its vicinity.

So far as I know, this article contains also the first published record of observations upon the geology of any part of Middle or Western Florida, and the first account of the discovery of Miocene strata in the State. For these reasons it has seemed worth while to publish the foregoing notes.

Leaving out of consideration, for the present, the beds of stratified drift, it appears further, that along the Gulf coasts of Alabama, of West Florida and of the Peninsula, the Post-Pliocene strata are directly superimposed upon the Vicksburg limestone; the intervening beds, representing the Miocene and Pliocene, being, so far as we now know, absent from those localities.

On the other hand, we know that in one locality certainly, and presumbly elsewhere along the Atlantic slope of the peninsula, a Miocene limestone overlies the Vicksburg.

While rocks of Pliocene age have not yet been recognized, it is reasonable to suppose that future explorations will reveal their existence along the eastern coast in a position similar to that occupied by beds of the same age in Georgia and South Carolina.

The facts with regard to the distribution of the rocks of Florida are presented in the following map.

Those points where the existence of the Vicksburg limestone has been determined beyond doubt, by fossils collected and identified, are indicated upon the map by a slightly darker shade. This formation was first recognized at Tampa and near the mouth of the Manatee River by Conrad; between Gainesville and Pilatka, by Professor J. W. Bailey; and at the other localities marked, by myself. The locality of the Miocene limestone was first observed by myself, and the Post-Pliocene age of the coasts and keys has been determined at many points by Conrad, Tuomey, Agassiz, LeConte and others.

Between the Post-Pliocene on the eastern coast and the Eocene of the interior, a space is left blank, as *undetermined*, except in one place, Rock Spring, where the Miocene limestone was noticed. In this area other occurrences of Miocene beds will probably be found.

Professor Tuomey states that the Vicksburg limestone is probably the country rock as far south as Charlotte Harbor.

Below that latitude, however, to the Everglades, the formation is a matter of conjecture, though laid down as probably of Vicksburg age.

In how far the construction of the map is justified by the facts observed, the reader has thus the opportunity of judging for himself.

Conclusions.

From the observations of others as quoted above, and from my own, I have been brought to the following conclusions regarding the past geological history of Florida.

1st. Since no rocks have been found in Florida, older than the Vicksburg limestone, it follows that until the end of the Eocene period, this part of our country had not yet been added to the firm land of the continent, but was still submerged.

Geological Map of Florida. By Eugene A. Smith.

Abbreviations, commencing to the westward: Mn., Milton; H. V., Holmes Valley; C., Campbelltown; M., Mariana; Ch., Chattahoochee; Q., Quincy; St. M., St. Mark's; L. O., Live Oak; L. C., Lake City; Ok., Okifinokee; P., Pilatka; Oc., Ocala; R. Sp., Rock Spring, adjoining Miocene locality, near middle of eastern part of Florida.—The bathymetric lines are from Mr. Hilgard's Map of the Gulf.

2d. During the period of disturbance which followed the deposition of the Vicksburg limestone (Upper Eocene), Florida was elevated nearly to its present height above sea level,

which elevation was maintained without material interruption until the Champlain period. Proofs of this statement may be found in the universal occurrence of the Vicksburg limestone as the country rock throughout the entire State, except perhaps in the southern part of the peninsula.

3d. In this upward movement, the axis of elevation did not coincide in position with the present main dividing ridge (north and south) of the peninsula, but lay considerably to the westward, probably occupying approximately the position of the present western coast.*

In other words, during the Middle and Upper Tertiary periods the Florida peninsula was much broader than it is now, toward the west; and while the eastern coast had nearly its present position, the western lay probably one hundred, in places perhaps one hundred and fifty miles beyond its present place. West Florida was also affected by this movement, and remained above sea level during the same periods.

Reasons for this conclusion are found in the total absence along the Gulf shores of West Florida and the peninsula, of all strata between the Vicksburg limestone and the Post Pliocene; while the peculiar beds of the Grand Gulf group of Hilgard overlie the Vicksburg limestone, on the Gulf borders of Mississippi, Louisiana and Texas, and a marine Miocene limestone of the usual Atlantic coast character, overlies the same rock on the eastern side of the peninsula.

This conclusion, reached as is seen above from purely geological considerations, finds a support amounting almost to demonstration, in the position of the one hundred fathom line off the Florida coasts, as shown on the accompanying map. It will be seen there that the submerged portion of the peninsula (within one hundred fathoms) on the west, is as wide as the present land surface, while on the east it is only a narrow strip.

That sediments were deposited during the Middle and Upper Tertiary periods off the Gulf coasts of Florida as well as of the other States mentioned is of course self-evident, and their absence along the coast at Tampa and elsewhere can be explained only upon the supposition that the coast line at that time was west of its present position, and that the deposits then made off that old coast are now submerged beneath the waters of the Gulf.

It may be objected that the absence of these deposits on the western coast is *apparent* and not *real:* that they have simply escaped notice: but it seems hardly probable that two such

* This assumes approximate uniformity of slope on each side of the main line of elevation. Under any other supposition, the facts would apparently require an elevation of the peninsula after the Vicksburg period, much above its present height, and a depression during the Miocene period at least thirty feet below present level.

close observers as Conrad and Tuomey should have overlooked them if they occur at least from Tampa southward.

4th. After the Miocene (or possibly after the Pliocene) period, there was again an elevation* of Florida, as is shown by the presence of a Miocene limestone on the eastern slope of the peninsula, some distance (not less than thirty feet) above present sea level.

The absence along the Gulf coasts, of Miocene and later Tertiary deposits, either of marine (limestone), or of brackish or fresh-water (Grand Gulf) origin, has already been accounted for above.

5th. We have evidence in the distribution of the beds of the Champlain period (Stratified Drift or Orange Sand), that Florida and parts of adjacent States were during this time submerged sufficiently to allow the deposition over them of a mass of pebbles, sand and clay, varying in thickness from a few feet to two hundred. The conditions under which these beds were deposited have been ably discussed by Hilgard in this Journal, and in his Mississippi and Louisiana Reports.

Of these conditions, I shall speak of one only. From the peculiar mode of stratification of most of these beds, it is concluded with reason, that they were sediments from rapidly flowing, ever varying currents. In the northern part of the State, the beds of red and yellow loam lie directly upon the Stratified Drift. These beds of loam are devoid of stratified structure as well as of fossils, and were probably deposited from slowly running or nearly stagnant waters.

The direct superposition of the Loam upon the Stratified Drift throughout Florida, Alabama and the greater part of Mississippi and Louisiana, and the fact that there is, with the exception presently to be noted, rarely, if ever, any sharp line of demarcation between the two—the upper beds of the Drift passing by imperceptible gradations into the Loam—point strongly to a community of origin, and appear to indicate that the Loam is the last of the sediments made by the floods of the Drift. Along the Mississippi River, the two are separated by the Port Hudson and Lœss deposits, both having more or less local characters; the Lœss being distinctly a river bank—and the Port Hudson, a river or gulf swamp deposit.

We can imagine that after the great rush of waters which deposited most of the pebbles and other coarse materials of our Drift, there followed, over the larger part at least of the Gulf States, a gradual checking of the currents and consequent deposition of the finer Yellow Loam, while along the axis of the Mississippi, where, as Hilgard has shown, the extremes of oscillation were experienced, this gradual change,

* On this point, compare foot-note on page 306, above.

from swiftly flowing to nearly stagnant waters, might have been interrupted by such subordinated and local oscillations as would have caused the formation of deposits like the Port Hudson and the Lœss.

6th. Following the submergence during the Champlain period, was a re-elevation, which brought up the peninsula with approximately its present configuration.*

Evidences on this point are to be found in the Post-Pliocene deposits described by Conrad, Tuomey and others, as bordering more or less uniformly, the eastern, southern and western shores, and forming the keys.

7th. In the height of these Post-Pliocene deposits above the present sea-level, Conrad and Tuomey see proofs of the elevation of the peninsula and keys (ten or fifteen feet) in still more recent times, while, on the other hand, Professors Agassiz and LeConte give a different explanation. To quote the words of the latter author: "Neither the mainland nor the Keys are anywhere higher than may be accounted for by the action of the waves, viz: from ten to fifteen feet."

8th. Since about one-fifth of the coast line of the Gulf of Mexico is formed by Florida, the present article would lack completeness if it did not take into account a theory or hypothesis which has been advanced in connection with the geological history of the Gulf region.

In view of the absence of marine formations of Middle and Upper Tertiary age along the Gulf coasts of Mississippi, Louisiana and Texas, and to account for the formation of the beds of the Grand Gulf group, without remains of marine life, which overlie the Eocene of those coasts, Professor Hilgard has been brought to the conclusion that during a part or the whole of the interval between the Vicksburg and Champlain periods, the Gulf was by some means isolated from the Atlantic, and thus converted into a fresh- or brackish-water basin, and he also further suggested that this was brought about by a land connection between Florida and Yucatan.

This hypothesis has been freely discussed in this Journal and elsewhere, and a further discussion of it would be to some extent foreign to this article, since the facts observed by me and recorded above, beyond proving that Florida during the Middle and later Tertiary periods, was part of the firm land of the continent, and was probably then nearly twice its present

* We can only speculate as to *when* and *how* the change from the broad peninsula of the Middle and later Tertiary periods, to the present narrow form took place. Two possibilities suggest themselves, viz: 1. At the beginning of the Champlain period, a more profound depression of the western as compared with the eastern half of the broad Tertiary peninsula; or 2. At the end of the period of submergence, the shifting of the main axis of elevation eastward, would have brought about this result.

width, have no direct bearing upon the hypothesis, and offer no solution of the main difficulty in the way of its acceptance, viz: the depth (7000 feet) of the straits between Yucatan and Cuba, and between Cuba and Florida (3000 feet).

And besides, so far as yet known, the Grand Gulf beds form no part of the *present* land surface of Florida, being now, as suggested in one of the conclusions above, probably submerged, if they ever formed a part of its Gulf coast deposits.

Appendix.

Lists of altitudes obtained from Maj. P. W. O. Kœrner, Engineer.

I. *Transit Railroad.*

Names.	Distances from Fernandina. Miles.	Altitude above low tide in Atlantic.	
Fernandina,	0	0	
Boggy River,	20	27 ft. highest elevation between these points.	Back tide water.
Callahan,	27	30 ft.	
Dutton,	36	45	
Baldwin,	47	47	
Maxville,	56	57	foot of Trail Ridge.
Summit of Trail Ridge,	61	210	
Western foot of Trail Ridge,	62½	180	
Laughty,	66	140	
Starke.	73	150	
Sante Fe (Lake Outlet),	79	137	
Waldo,	84	150	
Hatchet Creek,	91	(about 100)	
Gainesville (Court House),	95	128	
Arredondo,	100 (?)	70	
Archer,	107	70	
Sand Hills (Summit),	---	120	
Bronson,	127	27	
Otter Creek, (Gulf Hammock)	134	19	
Rosewood,	144	10	
Cedar Key,	154	0	

II. *Peninsular Railroad.*

	Names.	Elevation above low tide in Atlantic.	
Topographical Features near line of Road.	Sante Fe Lake,	137 ft.	
	Pithlachooke Lake,	85	
	Payne's Prairie,	68	Rim of Prairie about 100 ft. higher.
	Lochloosa Lake and Orange Lake,	52	
	Silver Spring,	39	
Stations.	Hawthorne,	150	
	Lochloosa,	60	
	Ocala (C. H. square),	100	
	Ridge 1 m. s. of Ocala (Hammock),	160	

The average elevation of the country between Ocala and Orange Lake is 80 ft.

University of Alabama, Dec. 15, 1880.

ART. XXXVII.—*The Magnetic Survey of Missouri;* by FRANCIS E. NIPHER.

IN the summer of 1878, the writer began a magnetic survey of the State of Missouri. The work of the first summer was confined to the northeastern part of the State, and no points of interest were brought out. During the summer of 1879 the work was extended over the western half of the State, and it was made apparent that diversity of surface exerted a much more important influence than had been suspected. The lines of equal declination were found to bend very sharply upon entering the large valleys, and the needle showed a tendency to set at right angles to the valleys. This tendency seemed to be greatest when the general direction of the valley made an angle of 45° with the normal position of the needle, or roughly, when the valley runs northeast and southwest or northwest and southeast. This tendency seemed to be inappreciable, when the valleys ran north and south or east and west. In the report of 1878,* it was suggested that this might result from the bending of the stream lines of the earth-current sheet, due to the greater conducting power of the moist valleys. In order to settle this point, further examination is necessary, and it is proposed to make determinations of earth currents at a number of properly selected stations.

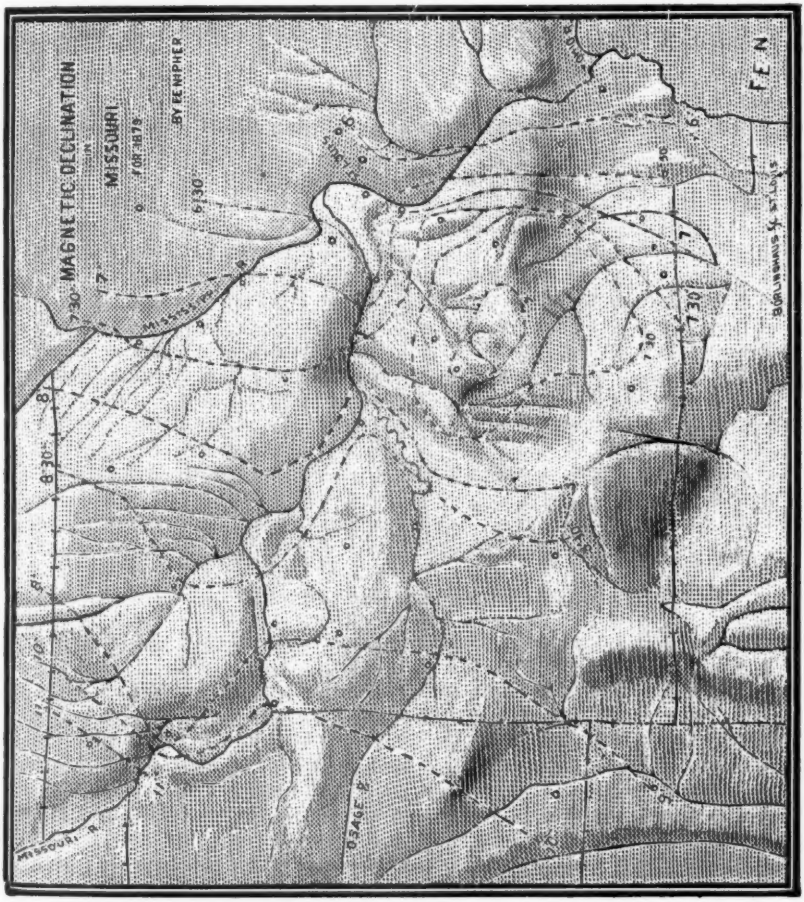
During the summer of 1880 the work extended over the southeastern part of the State, where still more important flexures of the isogonic lines were discovered. Here, however, the position of the needle is probably affected by the iron deposits, and the effect of contour is studied to less advantage. At the close of 1880, observations had been made at 45 stations. In order to bring out the effect of contour, a relief map of the State was constructed in wax, and was finally reproduced in plaster. In this work use was made of the profiles of all the railroads in the State, together with a list of over 300 elevations in the State collected by Henry Gannett. The isogonic lines which were first drawn upon an ordinary map in the usual manner to represent the observations thus far made, were then copied upon the relief map.

In doing this, it became apparent at once, that the 45 stations were wholly inadequate, and that the isogonic lines thus drawn are probably deserving of about the same weight that a topographical map would deserve if constructed from elevations at these stations.

The wood-cut is made after an artotype which will accompany the third annual report in vol. iv, no. 2, of the Transac-

* Transactions of the St. Louis Academy of Science, vol. iv, No. 1, p. 143.

tions of the St. Louis Academy of Science. In the original map, the horizontal scale is 20 miles to the inch, the elevations being exaggerated 200 times. This exaggeration was necessary in order to bring out the form in the photograph, since on



a relief map 150 feet square, the greatest difference in elevation in the State drawn to the same scale would be represented by a vertical height of one inch. The horizontal scale of the cut is 62 miles to the inch. Three stations in the Missouri valley

have been inadvertently omitted in the cut. One of these (Carrollton) lies on the 8° 30′ line, a few miles north of the river. Another (Glasgow) lies on the river, a little south of east from Carrollton. The third (Columbia) lies just east of the 8° line, and southeast from Carrollton. A fourth station omitted is nearly due east of the southern terminus of the 8° line, and just outside the 7° 30′ loop. The other stations, represented by the small circles are shown on the cut, and an inspection of the map will show the weight to be given to different parts of the lines. At stations situated at points of abrupt curvature of the lines, the observations have been repeated at various localities in the region, until it was clear that no minute local effects existed.

The value in the Iron Mountain region is the mean of many hundred determinations made with a solar compass by Pumpelly and Moore, in 1872. This region is in the east part of the 7° 30′ loop. In the western iron field, which is nearly coincident with the 7° oval, our observations were repeated at various points (our aim being to avoid iron deposits), without finding any local action. In conducting this survey, a magnetometer belonging to Washington University was used, but the dip circle and declinometer were kindly furnished by Professor J. E. Hilgard, of the U. S. Coast and Geodetic Survey. Thus far the survey has been conducted wholly on private means, in which we have been aided by the railroad companies, and by citizens of St. Louis. A bill providing for the completion of the survey is now before the legislature of the State.

ART. XXXVIII.—*On American Sulpho-Selenides of Mercury;* by GEO. J. BRUSH—*With analyses of Onofrite from Utah;* by W. J. COMSTOCK. Contributions from the Sheffield Laboratory, No. LXI.

AT a meeting of the National Academy of Sciences, held in New York in November last, Professor J. S. Newberry communicated to the Academy two papers, on the occurrence of various ores in Southern Utah, mentioning, among others, the discovery of a mercuric selenide at Marysvale, a mining camp two hundred miles south of Salt Lake City.

A specimen of this mineral was given me by Dr. Newberry, and desiring to ascertain more definitely its specific relations; I made a pyrognostic examination of it, and found it to be essentially a sulpho-selenide of mercury with traces of zinc and manganese, and that the mineral was probably identical with Rose's *Onofrite*. On communicating my results to Dr. New-

berry, he very kindly requested me to make a further investigation of the mineral, and placed in my hands an abundance of material for a quantitative examination. He stated that it occurs in what seems to be a fissure vein in a limestone, which he regards as paleozoic, and that the selenide was found at the bottom of a thirty-foot shaft, forming a seam about four inches wide.

Physical properties.—The specimens received from Dr. Newberry were, with a single exception, small irregular fragments, free from rock. The larger specimen was in a gangue of compact gray limestone, but the greater part of the specimen, 3 by 3 inches square and an inch in thickness, consisted of the sulpho-selenide. Even the limestone was found impregnated with the same, sometimes in visible specks, while in other portions of the rock it was not to be seen until acted upon by acid, or volatilized by heat in the closed tube. A small amount of associated crystalline calcite also included minute particles of the metallic mineral. The most careful scrutiny of the gangue failed to discover any native metallic mercury, or other associated metallic mineral, and there was no difficulty in selecting an abundance of the pure mineral for analysis entirely free from the gangue.

The mineral has a blackish gray color and streak. It has no distinct cleavage, but breaks with a conchoidal fracture and shows a brilliant metallic luster on freshly broken surfaces. The irregular natural surfaces of the specimens in my possession are somewhat spongy or cavernous in aspect, but afford no clue to the crystalline form of the mineral. The hardness is about 2·5 and the specific gravity of the mineral, boiled in water to free from air, gave the figures 7·61 and 7·63, in two determinations.

Pyrognostics.—In the closed tube the mineral decrepitates at first, then volatilizes for the most part, gives reactions for sulphur and mercury, coats the tube with a grayish black sublimate, and leaves a small non-volatile residue which is bright yellow while hot, and paler on cooling. In the open tube it gives sulphurous acid fumes, and sublimates of metallic mercury and sulpho-selenide of mercury, and leaves, as before, a slight residue of a yellow color. On charcoal in R. F., the assay tinges the flame blue, and in both O. and R. F., gives copious fumes with the characteristic disagreeable odor of selenium, and coats the coal with a sublimate having a metallic luster, which last, when touched with the R. F., disappears, tinging the flame azure blue. A slight non-volatile residue remains, which treated with soda, gives a faint zinc coating. When the residue obtained from heating in the tubes or on charcoal is fused with borax on platinum wire, it gives an

amethystine bead; with soda on platinum foil, it imparts to the flux the pale green color characteristic of sodium manganate.

Chemical composition.—The quantitative examination of the mineral was made by Mr. W. J. Comstock, assistant in the Sheffield Laboratory. He followed the method of H. Rose, decomposing the mineral by heating it in a stream of chlorine gas, and from the volatile portion, separating the selenium and sulphur by barium-chloride, weighing them as barium sulphate and selenate, while the mercury was separated from the filtrate from the baric precipitate as sulphide. To determine the sulphur, a separate portion of the mineral was dissolved by the aid of aqua regia and potassium chlorate, and then evaporated twice with chlorhydric acid to ensure the selenium being as selenous acid, when the sulphuric acid was precipitated by barium chloride. This precipitate was carefully tested and found to be entirely free from selenium. An examination was also made to ascertain if anything besides selenium, sulphur and mercury were carried over with the volatile portion, by the action of the chlorine gas, with a negative result. The non-volatile residue from this decomposition was found to contain only manganese and zinc. This was dissolved in water, and in the quantitative examination acidulated with acetic acid, and the manganese thrown down by bromine, in presence of sodium-acetate; from the filtrate, the zinc was precipitated as carbonate and weighed as oxide.

The following are the results of Mr. Comstock's analysis:

	I.	II.	III.	IV.	Mean.	Ratio.	
Selenium	4·69	4·47			4·58	·058	·423
Sulphur	---	---	11.62	11·73	11·68	·365	
Mercury	81·73	82·12			81·93	.409	
Zinc	0·61	0·48			0·54	·008	·429
Manganese	0·68	0·70			0·69	·012	
					99·42		

These figures prove the mineral to be essentially Hg(S, Se), or a mercuric sulpho-selenide, in which the ratio of the sulphur to the selenium is about 6:1. This brings it under the mineral species *onofrite*, which H. Rose found to be a mercuric sulpho-selenide, with the ratio of S to Se of 4:1, a relation which Rose evidently considered unimportant, for he remarks that mercuric selenide and mercuric sulphide, as isomorphous bodies, probably combine in all proportions.* The identity of the Utah mineral with onofrite is further established by their complete correspondence in physical characters, and Dr. Newberry's discovery of a considerable quantity of this rare species at a new locality is an interesting fact for mineralogical science.

In this connection it may not be amiss to review the occur-

* Poggendorff's Ann., xlvi, 318.

rence of native mercuric sulpho-selenides, which, thus far, I believe, have only been found on the North American continent. The first mention of a native sulpho-selenide of mercury is by Del Rio.* He found at Culebras, in Mexico, in a limestone which overlaid red sandstone, two ores, one red and the other gray; the former he described as "biseleniuret of zinc and bisulphuret of mercury," and the latter a "biseleniuret of zinc and sulphuret of mercury." The English mineralogist, Brooke, named the red mineral *culebrite*, after the locality, and the gray mineral *riolite*,† in honor of its discoverer. The gray mineral had a density of 5·56, and, according to Del Rio, contained Se 49, Zn 24, Hg 19, S 1·5 = 93·5. Subsequently, Del Rio, in a letter to Mr. Brooke,‡ announced that the riolite was "native selenium with a variable mixture of sulpho-seleniuret of mercury and the seleniurets of cadmium and iron." No further examination of the red mineral was made, and little confidence has been accorded Del Rio's results.

Nearly coincident with the publication of Del Rio's first paper, Kersten§ announced the discovery of a sulpho-selenide of mercury among some ores from Mexico, but no more precise locality was given. Kersten's mineral was associated with native mercury and sulphur in a gangue of calcite and quartz.

In 1839, H. Rose received from San Onofre, in Mexico, the blackish gray sulpho-selenide which he described and named *onofrite*.‖ This mineral was found in compact granular masses, associated with calcite and barite, and, according to Mr. C. Ehrenberg, one of the officials of the Real del Monte Company, the mineral occurred in such quantity that it was proposed to use it as an ore of mercury, although Rose had so little of the mineral for examination that he was unable to detach a sufficient amount of it from adhering barite to enable him to ascertain its specific gravity.¶

In 1865, Professor A. del Costillo, of Mexico, described** a sulpho-selenide of zinc and mercury from the quicksilver mines of Guadalcazar; this mineral was subsequently independently examined and analyzed by Petersen†† and named *guadalcazarite*. A more recent analysis of the same mineral is given by Rammelsberg in his Mineralchemie, p. 79. These minerals bear a close resemblance to one another in physical characters, as well as in chemical composition, as will be seen by the table of

* Phil. Mag. and Ann. Phil., vol. iv, (1828) p. 113.

† Rionite is another name given by some authors for the same mineral.

‡ L. and E. Phil. Mag., vol. viii, (1836) p. 262.

§ Kastner Archiv., xiv, 27.

‖ Loc. cit.

¶ In Dana's Mineralogy, 5th ed., p. 56, line 10 from bottom of page. the density given by Del Rio for his gray mineral is erroneously attributed to onofrite.

** Dana Min., 5th ed., p. 109, and Burkhardt, Jahrb. Min., 1866, p. 414.

†† Tschermak, Min. Mittheil., 1872, p. 69 and p. 243.

analyses given below. Furthermore, guadalcazarite approaches very nearly in composition the native black mercuric sulphide from California, discovered by Dr. G. E. Moore, and named by him *metacinnabarite*,* and, to complete the list of analyses for comparison, I add this, and also an analysis of tiemannite, the mercuric selenide from Tilkerode. The specific gravity of metacinnabarite is 7·70–7·74; of the Utah onofrite, 7·61–7·63; of guadalcazarite, 7·15; of tiemannite, 7·15–7·274.

	S	Se	Hg	Zn	Mn	Fe	Quartz.		
Metacinnabarite	13·82	---	85·79	---	---	0·39	0·25	=100·25	Moore.
Guadalcazarite	14·01	tr.	83·90	2·09	---	---	---	=100·	Rammelsberg.
do.	14·58	1·08	79·73	4·23[a]	---	tr.	---	= 99·62	Petersen.
Onofrite, Utah	11·68	4·58	81·93	0·54	0·69	---	---	= 99·42	Comstock.
do. San Onofre	10·30	6·49	81·33	---	---	---	---	= 98·12	H. Rose.
Tiemannite	0·70	23·61	74·02	---	---	---	---	= 98·33	Schultz.

(a) with trace of cadmium.

It will be noticed that guadalcazarite as analyzed by Rammelsberg differs from metacinnabarite only in containing a small amount (2·09 p. c.) of zinc. Nothing is known with certainty as to the crystalline form of any of these minerals, but a comparison of their densities renders it probable that they belong to the same system, and they may be considered as isomorphous mixtures of mercuric sulphide and selenide. Assuming this to be true in the case of the Utah onofrite, and taking the specific gravity of metacinnabarite at 7·70, and tiemannite at 7·27, we find that the calculated density is 7·64, while that observed for the mineral was 7·61–7·63, a remarkably close approximation. Onofrite may therefore be looked upon as an intermediary species with which may be classed the varieties of mercuric sulpho-selenide, which cannot be united with either metacinnabarite or tiemannite.

New Haven, January 12, 1881.

ART. XXXIX.—*The Effect of Great Cold upon Magnetism;* by JOHN TROWBRIDGE.

AN investigation upon the magnetic condition of steel, and upon the magnetic permeability of iron is now in progress in the Physical Laboratory of Harvard University. The preliminary experiments are interesting, since they show that very low temperatures exercise far greater influence on the magnetic condition than has been noticed by previous observers.

It is stated by Wiedmann,† that the cooling below the temperature at which steel is magnetized enfeebles the magnetic condition. A bar which was magnetized at 6° C. or 8° C. gave at 4° C. and −25° C. intensities represented by 5·08 and

* Jour. f. prakt. Chem., II, ii, 319, (1870) and this Journal, III, iii, p. 36.

† Daguin, Traité de Physique, nouv. ed. Influence de la temperature d'aimantation.

4·90. This represents a loss of less than four per cent. In my experiments the magnetic bar magnetized at 20° C. when subjected to a temperature of about −60° C. loses a far greater percentage of its magnetism. In one case a bar magnetized to saturation lost sixty-six per cent of its magnetism.

The low temperature was produced by solid carbonic acid and ether; and the magnetic moments of the bar were measured by placing it east and west of a suspended magnet, which was provided with a mirror. In this case we have the magnetic moment

$$M = \frac{1}{2} r^3 T \tan \varphi$$

where r=distance of magnet; T=horizontal intensity of earth's magnetism; and φ= angle of deflection of suspended magnet. The angles were observed before the magnetic bar was surrounded with the freezing mixture and afterwards at intervals when it was subjected, without removing it from its first position, to the influence of the carbonic acid. The following table shows the variations of the deflections to which the magnetic moments are proportional:

	When subjected to freezing mixture.				
Before freezing.	½ min. observ.	After interval of 3½ m.	½ m. obs.	1 min. obser.	2 min. obser.	5 min. obser.
·6390	·6050	·5860		·5820	·5790	·5540
·6395	·6020	·5850		·5815	·5740	·5515
·6390	·6000	·5840		·5825	·5700	·5480
	·5980	·5840		·5815	·5650	·5480
	·5965	·5830			·5600	
	·5950	·5820				
	·5940					
	·5930					
	·5920					
	·5910					
	·5900					
	·5890					

The zero of the scale was ·5000 and the observations are expressed in fractions of a meter. It will be seen that this bar lost in forty-seven minutes nearly two-thirds of its original magnetic condition. After twenty-four hours' exposure to the temperature at which it had been magnetized, its magnetic condition was fifty per cent of its original state.

A ring of soft iron was next experimented upon according to the method of Professor Rowland, and it was found that its magnetic permeability on being subjected to very low temperature differed greatly from the results obtained for soft iron at ordinary temperatures.

It is well stated by Dr. V. Strouhal and Dr. C. Barus, in a paper on the physical condition of steel, Ann. der Physik und Chemie, 1880, No. 13, that we must regard each bar of steel, in regard to its magnetic condition, as an individual of special characteristics—and a long investigation will be necessary to determine the limits of the effect of great cold upon magnetism.

ART. XL.—*Channel-fillings in Upper Devonian Shales;* by H. S. WILLIAMS.

IN the midst of the fine shales marking the passage from the Portage to the Chemung groups, as they appear in the neighborhood of Ithaca, New York, are found narrow beds of sandstone presenting several points of interest to the geologist.

The first example studied is seen at the mouth of the ravine opening where Junction, Elm and Hector streets meet at the foot of West Hill.

On the faces of the cliff on the north of the ravine are seen what appear to be wedge-shaped beds of sandstone of a few feet extent in the shales which form the main mass of the rocks. Upon a close examination these wedge-shaped masses are seen to be sections, formed at different angles (by the joint-structure of the rocks) of a continuous narrow bed of sandstone, convex on the bottom and nearly flat and horizontal on the top, running out to thin wedges at the sides, its longitudinal axis lying diagonally across both systems of joints.

By a reduction of the oblique sections as seen at several points of its exposure I determined the shape, size and direction of these sandstone masses, which I have called channel-fillings.

The first one studied is about six feet in width and nine inches thick at the center; the top nearly plane, while the under surface curves quite regularly from the center to each side.

The shales, in which the channel-fillings lie, are fine, evenly bedded, thin, fragile shales, the lines of stratification of which are uniform and horizontal.

Where they meet the channel-filling the shales are abruptly cut off, the former being solid, compact and showing no stratification. A fresh fracture of the sandstone shows faint horizontal lamination of color, but this lamination is scarcely at all recognized in any cleavage of the rock. At the upper surface a wavy lamination is seen in the coloration, and also in the cleavage planes an inch or so from the upper surface, which is continued in a more marked seam of arenaceous shale of uniform thickness indefinitely on both sides of the channel-fillings.

The material of the filling is nearly pure fine sand, while the enclosing rock is argillaceous shale with only slight admixture of arenaceous material. The dimensions (width and depth) do not appreciably vary for a distance of over one hundred feet (to the south side of the ravine where the section was discovered in the bank by following out the determined direction

across the ravine). The mass has its longitudinal axis in a line lying about 15° E. of N. and 15° W. of S.

The under surface of the sandstone masses present the appearance, frequently seen on flat flagstones from the Portage group, and called by Hall mud-flow or ripple marks.

In one case I thought I could *clearly* distinguish direction of flow of the runnels by the difference of degree of abruptness of the two sides of the two ridges and furrows. The abrupt side of the elevations seem to lie on the north side, and as these are casts I conclude that the flow which made them was in a southward direction.

In other cases I could not determine this point, and am still in doubt as to the cause of the inequalities on this lower surface.

Upon further examination of the ravines about Ithaca, I discovered that these channel-fillings are numerous, and distributed vertically through about twenty feet of shales.

The shale is well characterized by its fauna. Its termination is distinctly marked above by coarse arenaceous shales and sandstone, well known in the Chemung group, but these peculiar sandstone channel-fillings are not known to occur above or below this particular horizon.

Whenever, in the neighborhood the outcrop of the shales, with its characteristic fauna was discovered, careful search brought to light also the channel-fillings, everywhere running in a uniform direction, and varying in thickness from nine to eighteen inches, and in width from five and one-half to eight or nine feet.

The thicker beds were somewhat swollen in the center on top, and wrinkles, looking very much like the shrinkage wrinkles on the surface of a firkin of lard after it has cooled, were seen on the upper surface of these thicker masses.

The swollen center of these thick masses suggested the explanation, i. e., that subsequent to the original deposition of the rocks a certain amount of shrinkage took place in the shales which was not shared by the arenaceous channel-fillings, and thus the margins of the mass were borne down by the shrinking shales while the center of the mass, resisting the pressure, caused the center of the upper surface to bulge.

On the under surface of one mass of this kind, at the foot of Cascadilla ravine, I discovered the same fine lines trending in a general uniform direction which have been observed frequently on flat flags where they lie on argillaceous shales, resembling impressions of glacier scratches, and the trend of these lines is the same as that occurring on the Portage sandstones below, i. e., nearly due east and west. In the case mentioned the lines run diagonally down the one side the

channel across the bottom and up the other; some of the lines are fine and thread-like and appear entirely uninfluenced by the depth of the channel down and across which they swept.

These lines puzzle me much for explanation, and the only suggestion which appears to me worth offering is that of a swiftly moving tide or current trailing seaweeds or particles rapidly with it over the bottom.

To explain the channel-fillings there occurs to me only one series of events which begins to cover the facts. The uniformity, structure, directness and great number of the channels seems to preclude the idea of a rapidly flowing stream across a beach, and the continuity of the imbedding strata seems consistent only with under-water work.

The suggestion I have to offer is, that these channels were caused by the scratching of icebergs on the shoals represented by the imbedding shales; that the channels were then scooped cleanly out of the mud of the bottom; that the flow or runnel marks were caused by the same ocean current which bore along the icebergs, and perhaps increased in the wake of the berg.

The deposit of sand in the channels was due to the catching of the heavier sand (in the cavity thus formed) more rapidly than on the general surface represented by the thin arenaceous layers above; and I suppose it therefore to have been filled during the deposit of this thin stratum of arenaceous shale which is continuous with the upper layers of the channel-filling, and which it will be remembered is uniformly uneven with ripple-mark structure; showing that during its deposit there was considerable motion in the depositing medium, carried by tides or currents.

Before closing, it may be interesting to mention that the richest locality known of the commoner of the beautiful and graceful fern-like fronds, called *Lycopodites Vanuxemi* by Dawson, but considered to be allied with the graptolites, and named *Plumalina plumaxia* by Hall (see 30th Reg. Rep. N. Y., p. 255) is in the stratum immediately overlying one of the thickest of these channel-fillings. The stratum is a soft shale and for an inch or so in thickness is filled with these and other plant remains, with a few species of frail shells, avicula, lingula, etc., in greater or less abundance. The same stratum has yielded a large fish plate closely resembling the plate C of the ventral shield of Newberry's *Dinichthys Terrelli* from the Huron shale of Ohio (see Pal. Ohio, vol. ii, chart No. vi, and p. 31). The specimen found at Ithaca is about half the size of the Ohio specimen figured. The shales in which the channel-fillings are seen is characterized by the presence of a Lingula which I believe to be new, at least as a variety and probably as a species, and which I propose to describe at another time.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Atomic Weight of Aluminum.*—By the courtesy of Professor J. W. Mallet, we have received a copy of his paper upon the atomic weight of aluminum. After a review of the labors of other chemists, Berzelius, Davy, Thomson, Mather, Dumas, Tissier and Terreil, as well as his own previous investigations in this direction, the author passes to a description of the special research in hand, a research which occupied three years of his time and which appears to us to be a model of painstaking investigation. The principles kept in view in selecting the methods were: "1st, that each process used should be as simple as possible, and should involve as little as possible of known liability to error; 2d, that different and independent processes should be resorted to as the means of checking each other's results, even though it may fairly be assumed that one is more advantageous than another; 3d, that each process should be carried out with quantities of material differing considerably from each other in successive experiments; and 4th, that only such other atomic weights should be involved as may be counted upon among those already known with the nearest approach to accuracy." All the reagents used were tested with the greatest care, vessels of hard porcelain or platinum replacing those of glass. The weighings were made on a Becker balance in perfect order and carefully adjusted. Where absolute weights were required the method of double weighing was employed. The weights were carefully compared with the standard kilogram in the Office of the Coast Survey, the relation of which to the kilogram of the Archives is known. The density of each weight used was determined, as also that of all vessels and materials which had to be weighed. The barometer and thermometer being noted at the same time with the weights, these latter could easily be reduced to vacuo. Three methods of determining the atomic weight were employed, a series of experiments being made by each method. These were: 1st, the ignition of ammonia alum; 2nd, the precipitation of the bromine in aluminum bromide by silver; and 3d, the evolution of hydrogen by the action of metallic aluminum upon sodium hydrate, the hydrogen being determined (1) by the direct measurement of its volume, and (2) by weighing the water produced by its oxidation. The ammonia alum of commerce, carefully purified from iron, and repeatedly recrystallized, was used in the first process. The aluminum hydrate was precipitated by ammonia free from the alcoholic amines, well washed, dissolved in hydrochloric acid and reprecipitated twice, then dissolved in sulphuric acid, the necessary quantity of pure ammonium sulphate added, and the alum recrystallized three times. The ignition was effected in a platinum crucible, to the cover of which was attached a wire carrying two perforated diaphragms to prevent the loss of

solid particles. After ignition at a bright yellow heat for an hour, inside of a second crucible, it was cooled and moistened with a strong solution of ammonium carbonate, and re-ignited. The crucible containing now pure Al_2O_3, after cooling was placed in a specially constructed glass bottle and weighed. For the second method, aluminum bromide was prepared directly by the action of bromine upon aluminum and carefully purified by repeated fractional distillations until it was perfectly white and boiled steadily at 263·3° under 747 mm. pressure, the last distillation being effected in a current of nitrogen. Pure silver was prepared and dissolved in pure nitric acid, the solution being used to precipitate the aluminum bromide. The amount of silver used was something less than required to completely precipitate the bromine, the process being completed by adding a graduated solution of silver from a burette. For the third series, pure metallic aluminum was prepared by reducing pure aluminum bromide by sodium in presence of potassium and sodium chlorides in a Beaufaye crucible lined with a mixture of alumina and sodium aluminate. A known weight of the pure metal was dissolved in a solution of sodium hydrate prepared from metallic sodium. The hydrogen was collected in carefully calibrated flasks over mercury in the first set of experiments, and reduced to the normal volume. In the second set, the gas was passed through a combustion tube containing cupric oxide, the water produced being collected in a calcium-chloride tube, a sulphuric acid and pumice tube and one containing phosphoric oxide, used successively. For the details of these experiments and the minute precautions used we must refer to the original memoir. In calculating the results of these experiments, the atomic weights of Dumas and Stas were used, viz: for O, 15·961; for S, 31·996; and for N, 14·010. As to bromine and silver, correction was made for the oxygen occluded by the silver in Stas's research, and thus the atomic weight of silver became 107·649 and of bromine 79·754. The results as calculated were as follows: 1st method, series A gave 27·040±·0073 as a mean of five experiments; series B, 27·096±·0054, also a mean of five. Second method, series A gave 27·034±·0049, series B 27·023±·0052, series C 27·018±·0069, A and C being from three experiments and B from five. Third method, series A gave 27·005±·0033 as a mean of six, and series B 26·990±·0046 as a mean of three experiments. Series A of the third method the author thinks entitled to most weight and series B, first method, to the least. The mean of all thirty experiments gives Al = 27·032±·0045. If 1, B be excluded, Al=27·019±·0030. Hence the atomic weight of aluminum is 27·02, or when integers are used for O, N, C, Na, etc., 27. The paper closes by calling attention to the fact that of the eighteen elements whose atomic weights have been determined with the greatest possible precision, ten approximate to integers within less than one-tenth of a unit. Hence the law of Prout would seem to deserve a reconsideration.—*Phil. Trans.*, 1003, 1880. G. F. B.

2. *On the light which appears on Metallic Electrodes which are placed in hydrogen gas at different pressures.*—O. LOHSE describes the spectroscopic appearance of glowing metallic electrodes placed in an atmosphere of hydrogen and of magnesium vapor. The apparatus consisted merely of suitable vacuum tubes, induction coils and a spectroscope. It appears from the observations that the dependence of the formation of metallic vapor upon the density of the gas surrounding the metallic electrodes can be studied quantitatively by the use of a constant current of electricity. It is also perceived that with increasing rarefaction of the hydrogen the light intensity of the metallic vapor increases in the more refrangible portion of the spectrum.—*Ann. der Physik. und Chemie*, 1881, No. 1. J. T.

3. *The b line in the Solar spectrum.*—Professor C. A. YOUNG, by means of a Rutherfurd grating of 17280 lines to the inch, and by means of the spectrum of the third order, has discovered that b_3 and b_4 are double and are distant from each other one-sixth of a unit of Angström's scale; also, that the line 5207·4 is double. These observations possess great interest, because it is claimed by Lockyer that these lines are basic—b_4 belonging to Fe and Mg, b_3 to Fe and Ni, 5207·4 Cr and Fe.—*Observatory*, 1880, p. 271–272; *Beiblätter Ann. der Physik und Chemie*, 1881, No. 1.

J. T.

4. *Action of an intermittent beam of radiant heat upon Gaseous matter.*—Professor TYNDALL in a paper read before the Royal Society, Jan. 3, 1881, reviews the criticisms of various experimenters upon his investigations in radiant heat, and believes their interpretations to be due to a failure on the part of the critics to recognize the strength of his position as a whole. He has taken up the subject anew and proposes to submit the results in due time to the Royal Society. In the meantime he has experimented upon gaseous matter with Mr. Bell's photophone. Reasoning that highly diathermanous bodies would produce faint sounds while highly athermanous bodies would produce loud sounds, it seemed that the strength of the sound could be made the measure of the absorption. He proceeded to test the truth of this reasoning by experiment. The first source of rays was a Siemen's lamp connected with a dynamo machine worked by a gas engine. A glass lens was used to concentrate the rays, and afterwards two lenses. A circle of sheet zinc provided at first with radial slits and afterwards with teeth and interspaces was caused to rotate rapidly across the beam near the focus. A flask containing the gas or vapor to be examined was placed immediately behind the rotating disc. From the flask a tube of India rubber ending in a suitable tapering one of ivory or box-wood led to the ear. Afterwards silvered mirrors were used in place of the lenses.

Sulphuric ether, formic ether, and acetic ether were placed in bulbous flasks and their vapor was diffused above the liquid. Loud musical sounds were heard when the intermittent beams passed through the vapor. These are the most highly absorbent vapors

which Professor Tyndall had previously experimented upon. Very faint sounds were obtained from chloroform and bisulphide of carbon which are diathermanous. It was found that it was the vapor and not the liquid which is effective in producing the sounds. In general, the power of vapors to produce musical sounds can be accurately expressed by their ability to absorb radiant heat. Dried air, dry oxygen and hydrogen gave scarcely any effect. Carbonic acid gave a louder note than any of the elementary gases. Thus it was found that the gases stand in the same relation to the production of musical sounds that they occupy in regard to the absorption of radiant heat. The vapor of water was next tried and Professor Tyndall heard with delight a powerful musical sound. The method is then enlarged upon as a very delicate one to test the athermancy or diathermancy of gases and vapors. In a subsequent communication to the Royal Society, Professor Tyndall renews his enquiry into the effect of an intermittent beam upon aqueous vapor and confirms the results obtained by him nineteen years ago, and believes these results to be in entire disaccord with those obtained by experimenters who have ascribed a high absorption to air and none to aqueous vapor. In the later experiments a lime light was substituted for an electric light, and it was shown that the light of a candle was sufficient as the source of the intermittent beams. The author concludes that the vapor of all compound liquids will be found sonorous in the intermittent beam, and since he questions whether there is in nature an absolutely diathermanous substance he believes even the vapor of elementary bodies will be found to be capable of producing sounds.—*Proc. Royal Society*, Jan. 3 and Jan. 10, 1881. J. T.

5. *On the tones which arise in a gas as the effect of intermittent radiation.*—Professor W. C. RÖNTGEN has also recently investigated the effect of an intermittent beam of heat-rays in producing musical tones in a gaseous medium, being led to this series of experiments by the announcement of Professor Bell's results with the photophone. As the source of heat a Drummond calcium light was employed. The rays were concentrated by two lenses on a disk of pasteboard provided with a series of openings; the dish was arranged so that it could be rapidly and silently rotated about a horizontal axis. Behind the openings in the disk was held the absorption apparatus; this consisted of a tube 12 cm. in length closed by plates of rock salt; in the side of this was attached a short (1 cm.) tube closed with a piece of rubber cloth, which could be inserted in the ear of the observer. When the disk was rotated the heat rays alternately fell upon the absorption tube and were cut off from it, producing thus an intermittent effect. The tube was filled at first with air, but no effect could be heard. When, however, coal gas was introduced in the tube a very distinct tone was heard resembling the whistling sound produced by a strong wind. The strength of the tone did not change perceptibly with the time during which the tube was exposed,

but the tones ceased immediately when the rays were cut off by an opaque body, as the hand, or a piece of board placed before the disk. A solution of alum placed in the path of the heat rays also caused the disappearance of the tones, while no perceptible weakening was noted when the rays were made to pass through a layer 10 cm. thick of a solution of iodine. With ammonia distinct tones were also obtained, but dry hydrogen and oxygen behaved like atmospheric air. The cause of these phenomena is explained to be the alternate warming and expansion and the rapidly following cooling and contraction of the absorbing body, and, as might be expected, the effect was most distinct in the case of gases which have a strong absorptive power. The author closes by expressing the intention of determining the behavior of water vapor in this respect, with the view of deciding the question as to whether or not it exerts a strong absorptive power on the heat rays (see preceding notice, and p. 236, March, 1881).—*Ann. der Phys. u. Chem.*, Jan. 1881.

II. Geology.

1. *International Geological Congress at Bologna.*—The second meeting of this Congress will be opened on the 26th of September next, under the presidency of Sign. Quintino Sella. Sign. J. Capellini, at Bologna (65 Via Zamboni), is president of the Committee of Organization, and to him all correspondence should be addressed. The Congress at Paris in 1878 appointed two committees, to make reports at Bologna: one on the unification of geological methods of representation on maps and sections by colors and otherwise; a second, on the unification of geological nomenclature. A third was appointed to consider the question of rules of nomenclature of species in mineralogy and paleontology. The first of these Committees consists of Mr. Selwyn, of Canada, President; M. Renevier, of Lausanne, Secretary; and of Messrs. Ramsay, Liversidge, von Hauer, von Hantken, Gümbel, von Möller, Torell, Dupont, De Chancourtois, Giordano, Ribeiro, Lesley. The members of the second are, M. Hébert, of Paris, President; M. Dewalque, of Liège, Secretary; and Messrs. Hughes, Liversidge, Capellini, A. Favre, Rœmer, Szabo, Stephanesco, Inostranzeff, Lundgren, Vilanova, James Hall, Sterry Hunt. Those of the third, are, for Paleontology, Messrs. Cotteau, Douvillé, Gaudry, Gosselet, Pomel, De Saporta; and those for Mineralogy, Messrs. Des Cloizeaux and Jannettaz.

Persons intending to be present at the Congress are desired to give early information to Signore Capellini, stating fully their place of residence and particular department of study. The fee for members will be twelve francs; and this entitles the person to the "Compte rendu" and other ordinary publications of the Congress. The certificates of membership will be delivered at Bologna after September 20th.

M. Renevier, Secretary of the first of the Committees, has published a pamphlet, containing some of the reports on the colors for

geological maps received by him from several of its members. In these reports the recommendation from the Swiss Committee agrees with those of France and Italy in proposing to distinguish the Cretaceous by a *green* color; Jurassic, by *blue;* Liassic, by *violet;* Triassic, by *brick-red*, Permo-carboniferous, by *gray*, and crystalline schists, by *rose-carmine*. It suggests *bright yellow* for the Eocene Tertiary, *pale brown-yellow* (jaune chamois) for the Miocene, and very *pale sepia* for the Pliocene and Quaternary together. The French propose *pale yellow* for Eocene, *reddish yellow* for Miocene, *red* for Pliocene and very *pale green* for Quaternary, and the Italian, *bistre* for Eocene, *reddish yellow* for Miocene, *clear yellow* for Pliocene, and very *pale green* for Quaternary. For the Devonian and Silurian, the Italian, French and Swiss have proposed but one color—evidence that the countries contain little of either of these formations.

2. *Geological terms for Stratigraphical Subdivisions.*—Looking at the earth's strata as a historical series, it becomes natural to divide geological time into ages or eras, periods and epochs. But in descriptive geology it is indispensable also that they should be subdivided stratigraphically. In English geological works the terms commonly employed for this latter purpose are: *formation*, *system*, *series*, *group*, *beds*, but with varied use. *Formation* and *system* are often interchanged; but (as also in Germany) the latter term has most general use. *Series*, *groups* and *beds* are variously employed, but almost always subordinately to formation or system. The word *terrane*, from the French *terrain* and Italian *terreno*, has been employed, but without defined restriction.

Prof. G. Dewalque, in vol. vii of the Memoirs of the Geological Society of Belgium (issued Feb. 1881), has discussed the signification of the terms used in French and Belgian works on geology, namely, *formation*, *terrain*, *système*, *étage*, *assise*, *zone*, *couche*. He cites D'Archiac's protest in 1847, against the confusion as to their use at that time in France, and shows that the confusion is hardly less now. He favors the rejection of the terms *formation* and *group* and would confine the former to its literal signification when reference is to be made to rocks of a kind as *calcareous formations*, *granitic formations*; and gives as the best terms and their best order, commencing with that of broadest signification, *terrane*, *system*, *stage*, *substage*, the last, made synonymous with "*assise*," and *group;* adding that the terms *series* and *zone* (the latter when characterized by particular fossils), may sometimes be used with convenience, though not made to distinguish any particular grade of subdivision.

As an example of his scheme, he cites part of a table of geological subdivisions by Renevier. In this table the Jurassic *terrane* includes four *systems*, the Portlandian (Portland beds); Corallian (coral rag); Oxfordian (Oxford oolite) and Bathonian (Bath oolite); and each of these *systems* contains three to four *stages*, e. g., for the Portlandian *system* the three *stages*, Purbeckian, Portlandian and Kimmeridigian; and so on.

The scheme sets aside English usage altogether—which would write (1) Jurassic *system* or *formation;* under this, Portlandian *group* or *series;* and, under this, Purbeckian (or Purbeck) *beds.* As is seen, it gives to the term *system* a place subordinate to *terrane*, and recognizes *four systems* in the Jurassic *terrane*; when the expression *four series* would imply about all there is of true system in the succession of beds. System exists in the geological formations chiefly through the fossils; but the system so founded is geologically of the most comprehensive kind, and hence the term *system*, if used, should be given to the grander subdivisions. But it is much better to have, in place of the abstract term *system*, one that refers directly to the objects classified, such as *terrane* or *formation*, because it is more appropriate and more pliant. D'Archiac, after systematizing his views on the subject, uses, in the later volumes of his *Histoire*, the term *formation* for the highest grade; then *group;* then *stage.* It is probable that a compromise might most easily be effected by adopting the term *terrane* for the highest grade, it having been already accepted in France, Belgium, Switzerland and Italy; and for the second grade, the term *group*, which has the widest usage in its favor. The scheme, thus modified, would be—putting in for the lowest grade two terms for choice:

(1) Terrane; (2) Group; (3) Stage; (4) Beds or Substage.

The desirableness of agreement on some common terms for Europe, Britain and America is beyond question. J. D. D.

3. *Metamorphic rocks—gneiss, mica schist, crystalline limestone and others—containing fossiliferous beds.*—The occurrences of fossils in connection with metamorphic rocks are facts of great geological interest, especially since they instruct as to the several periods in the past when such rocks have been formed, and throw much light on the true value of any determinations of the age of crystalline rocks based on their mineral constitution. Facts of this kind are here cited from two papers published in the Atti Soc. Toscana di Scienza Naturali (Pisa) of Nov. 14, 1880.

The first, by Professor G. Meneghini of Pisa, gives an account of *the occurrence of Orthocerata in limestone contained in beds of gneiss and mica schist in the Apuan Alps.* The strata in the Apuan Alps (situated to the northwest of Lucca, parallel with the coast), near Fociomboli and Puntato, include beds of thin schistose gneiss and mica schist, with other beds and marble above. In the lower of these groups, in the mica schist, about twenty feet below its top occur lenticular masses of limestone (making it a calciferous mica schist); and this limestone has afforded Meneghini a number of specimens of *three* species of *Orthocerata.* Two of them have a circular section, and a central siphuncle, and resemble Triassic species; but the third is elliptical in section, has an eccentric siphon, very short chambers, and is nearest to Paleozoic kinds, with which also the other two have near relations. At Mosceta, other specimens were found in calcareous beds in the upper schists of the series, part of which may be the same with

no. 2, and others that are like no. 3, and have some affinity in interior structure to *Ormoceras tenuifilum* of Hall, and *O. crebriseptum* of Hall.

The second of the papers referred to, by C. De Stefani, reviews the facts as to the *Equivalency of the formations of the Apuan Alps* about Tirreno, Serchio, Fiume di Gragnana, Canale di Sermazzana, Aulella and Magra. The following facts are taken from his enumeration of the rocks of the Paleozoic and Mesozoic formations, with the name of the author who determined the true equivalency.

The Paleozoic beds include mica schist, damourite schist, gneiss, chloritic damourite gneiss, chlorite schist, chloritic argillyte, ottrelite schist, graphite, schistose crystalline limestone, bluish, cipolin, and other marbles.

The Triassic, overlying the Paleozoic, include (De Stefani, 1874,) the ordinary "grezzoni" and also albite-bearing magnesian and carbonaceous varieties, which contain Triassic fossils in Mt. Sagro, at Vinca (Savi in 1846), in Carchio, Corchia, and at other places; (2) Marbles, ordinary white, gray, cipolin (greenish to gray and brownish talcose), the statuary of Trambiserra, of Corchia, etc., and also mica schist and chloritic mica schist; and in overlying beds (*b*), other marbles both architectural and statuary, besides quartzyte, jasper rock, *staurolite schist*, damourite schist, graphite, chloritic damourite gneiss containing oligoclase, the latter with impure limestone; with Triassic *fossils in the bardiglio and other limestones* at Tambura, Roccandagia, and numerous other localities; also, at top (*c*), arenaceous beds, slates, gray and other limestones, with traces of fossils, and among them *Encrinus liliiformis*, species of *Cidaris*, *Pentacrinus*, *Chondrites*, etc.

Next follow the subdivisions of the Lias, the Tithonian or Purbeck and Wealden, the Neocomian and Gault of the Cretaceous, and the Tertiary.

4. *Bulletin of the U. S. Geological and Geographical Survey of the Territories*, F. V. Hayden U. S. Geologist-in-Charge. Vol. VI, No. 1.—The first article in this number of the Bulletin is on the Vegetation of the Rocky Mountain Region, by Asa Gray and Joseph D. Hooker. Then follow—by E. D. Cope, on New Batrachia and Reptilia from the Permian of Texas, on a Wading Bird from the Amyzon Shales, on the Nimravidæ and Canidæ of the Miocene, and on the Vertebrata of the Wind River Eocene of Wyoming; by R. W. Schufeldt, Osteology of *Speotyto cunicularia* var. *hypogæa*, and of *Eremophila alpestris;* by A. R. Grote, a Preliminary list of the N. American species of Agrotis.

The *Amyzon shales* of Cope are Tertiary lacustrine beds "in the South Park of Colorado, in N. E. Nevada and probably in Central Oregon," including those of Florissant; they are Upper Eocene or Lower Miocene. A bird from them of the Fringillidæ, *Palæospiza bella*, was described by J. V. Allen, in 1878 (Bulletin, iv, 443). The new *wading bird* is named by Cope *Charadrius Sheppardianus*, and was from near Florissant.

5. *Description of the Coal Flora of the Carboniferous Formation in Pennsylvania and throughout the United States;* by LEO LESQUEREUX. Vol. II. 1, *Lycopodiaceæ;* 2, *Sigillariæ;* 3, *Gymnosperms.* Report P of the Second Geological Survey of Pennsylvania. Harrisburg, Pa., 1881.—The text of the coal flora of L. Lesquereux's report is nearly ready for distribution; the atlas containing illustrations of the many species has been out for nearly two years. The following statement of the contents of the volume has been received from the author.

The first part of the report, covering 600 pages, contains along with an exhibition of the essential characters of the groups, families and genera, descriptions of 635 species of coal plants.

This part is followed by general remarks in chapters headed as follows: 1st. The nature of the vegetation of the Carboniferous era and its agency on the economy of the world, giving the history of the formation of the coal and a discussion of the different theories on the subject. 2d. The geographical and stratigraphical distribution of the Coal-measures. 3d. The amount of material comprising the flora. 4th. The United States coal flora compared with that of Europe. 5th. The geographical distribution of the plants in the Coal-measures. 6th. Their stratigraphical distribution, with a table of distribution of the species. 7th. On the origin, succession and modification of the vegetable types from the base of the Coal-measures upward.

This brings the work to the 684th page, after which follow the literature, containing an enumeration, with titles, of the works quoted in the flora, an index of localities, and another index of the Latin names.

III. BOTANY AND ZOOLOGY.

1. *The British Moss-Flora;* by R. BRAITHWAITE, M.D., F.L.S. —Dr. Braithwaite, having by his *Sphagnaceæ or Peat-Mosses of Europe and America* assured his position among bryologists, in the present work undertakes a series of monographs of the true Mosses of Great Britain, to be issued in parts, in systematic order. Three parts are already issued of this work, which is to comprise descriptions, full synonymy, and detailed illustration from the author's own drawings, of all the British species. These parts complete four families of the Acrocarpous Mosses, from *Andreæaceæ* to *Polytrichiaceæ* inclusive, the order and classification followed being that of Lindberg. The fourth part is announced to contain the *Fissidentaceæ*. The form of the book is imperial octavo, the letter-press full and all in English, the synonymy seemingly complete, and historical and critical matter well chosen and sufficiently abundant. The plates are admirable, not only for the drawings and judicious selection of the details, but for the lithography, which, so far as we know, is unequalled by anything of the kind in England. One thing only we should on our part desire, and may hope the author will in future supply;

and that is the geographical range of the species, at least as respects the northern hemisphere. For the British species being almost all indigenous to North America also, and this work being so satisfactory and of comparatively small cost and withal so handsomely executed, we should expect a fair demand for it in the United States, both from public libraries and from a good number of bryological students. To facilitate the acquisition of the work in this country, we may state that the talented author is his own publisher; that the price is fixed at the rate of one shilling per plate (on an average so far of about three species to a plate), letter press included, that a prepayment of 10*s.* 6*d.* will serve for a section of twelve plates and free delivery by post to any part of the United States; and that this may be made by money orders to R. Braithwaite, 303, Clapham Road, London, payable at Clapham Common office. The first section of twelve plates will be completed by the monograph of *Fissidens*, with three plates, now on the eve of publication. A. G.

2. *On the Origin of starch grains;* by A. F. W. Schimper. (Botan. Zeit., 1880, and now published separately.)—The relations of the shape of the chlorophyll-grain to the form of the starch granules produced therein, are explained at some length, and the differences in the form are shown to be dependent upon the direction of the supply of nutritive material. Since the location and the course of the material from which the starch of the chlorophyll-grain originates cannot be the same for all parts of the grain, it necessarily results that the starch deposited must be unsymmetrical in form. But this lack of symmetry is more than simple irregularity; it is governed generally by the shape of the grain of chlorophyll in which the process takes place.

The production of starch in cells which are devoid of chlorophyll, and where of course the greater part of the supply of starch is deposited, is shown to be largely dependent upon the presence in the non-assimilating cells of highly refractive ellipsoidal bodies (sometimes spindle-shaped). Under the influence of light these bodies may be converted into chlorophyll granules. They are presumably identical with the bodies termed by Nægeli "*Brutblaschen*," and which were also noticed by Trécul. The different forms of these starch-producing bodies and the characteristic shapes which the deposits assume, are conveniently classified. The author holds a view which must steadily gain ground; namely, that the starch which occurs in chlorophyll granules is not the primary product of the assimilative process. The re-examination of this subject by Pringsheim and by those who have repeated his experiments, has excited a renewed interest in one of the most important as well as most difficult fields of research. This valuable paper is copiously illustrated. G. L. G.

3. *Botany of California*, Vol. II; by Sereno Watson. Cambridge, Mass., John Wilson & Son, University Press, 1880. —The first volume of this flora appeared in 1876, and bore on the title-page the names of W. H. Brewer and Sereno Watson as

authors of the *Polypetaleæ*, and Asa Gray of the *Gamopetaleæ*. That the work is now finished is due mainly to the indefatigable industry of the botanist in whose name it is issued; that it is published, as we learn from a preparatory note, is owing chiefly to the zeal and liberality of Hon. S. C. Hastings, who solicited and obtained the necessary pecuniary means for this purpose. His fellow-contributors for the present volume were D. O. Mills, Henry Pierce, Leland Stanford, J. C. Flood and Charles Crocker, all of San Francisco.

The volume contains the Apetalous orders, the Gymnosperms, the Monocotyledonous orders, and the higher orders of Cryptogamous plants. As is usual in works of this character, some portions are contributed by special collaborators, Dr. Engelmann writing the Oaks, the Mistleto family and the Pines, Spruces, etc., Mr. Bebb the Willows, Mr. William Boott the Carices, Dr. Thurber the Grasses, and Professor Eaton the Ferns and Fern-allies.

To say that Dr. Watson's work bears evidence of being very carefully done, that his classification is mainly conformed to the approved modern standard of the British botanists, that his technical characters, of orders, genera and species, are concise yet exact and reasonably full, that his statements of habitat and range are well studied, and that his remarks appended to the generic and specific descriptions are judicious,—is too feeble praise. The work is more than good; it is admirable; it is in advance of anything of the kind which has ever been seen, and will long serve as a model for a flora, and as an exalted standard.

The author's great ability as a writer of Systematic Botany is especially evident in his treatment of the Mosses of the Pacific States. He has not been hitherto classed among American Bryologists, and has certainly not devoted year after year to the microscopic study of these little plants; but he has had before him the writings of Sullivant, Schimper, Lesquereux, Mitten, James, Austin, Mueller and others, as well as the rich collection in the Harvard Herbarium, and he has collated and reduced to one well-digested system the whole mass of abundant and often contradictory material, more successfully, impartially and judiciously than any living specialist could have done. The conspectus of the genera of Mosses must be regarded as a triumph of the art of applying to one class of plants the judicious systematic facility acquired in the study of other classes.

The many additional species of polypetalous and gamopetalous plants which have been collected in California since the first volume was published, together with a few additions to the second volume, are given in the latter part of this volume, making the whole complete up to the summer of 1880. Then follows an index to the whole work, a concise glossary of technical terms, and a very interesting "list of persons who have made botanical collections in California." This is more than a list of names, for it gives some brief account of all known collectors of Californian plants from Thaddeus Hænke, in 1791, to S. F. Peckham, in 1866. The principal more recent collectors are also mentioned.

The first volume, it will be remembered, bore on the cover a blossom of some prickly cactus, or *Cereus*, with the legend "E SPINIS FLOS," alluding doubtless to the blossoming out of the work from the midst of thorny difficulties. The second volume bears in like manner a branch and cone of the "big tree," *Sequoia gigantea*, with the motto, at once triumphant and prophetic, "RES TEMPORE MAGNA." D. C. E.

4. *The Gymnosporangia or Cedar-apples of the United States;* by Professor W. G. FARLOW. From the Anniversary Memoirs of the Boston Society of Natural History. 4to. pp. 38, pl. 2. Boston, published by the Society, 1880.—The results of Oersted's experiments on Gymnosporangium and Rœstelia, made some fifteen years ago, being quite generally accepted as evidence of their genetic connection, any consideration of the one naturally includes the other; hence the present paper is a monograph of both genera as represented in our country. From their structure the author recognizes the following species of Gymnosporangium, including Podisoma: *G. Ellisii* (Berk.), *G. clavariæforme* DC., *G. macropus* Lk., *G. fuscum* DC., *G. fuscum* var. *globosum* Farlow, *G. biseptatum* Ellis, *G. clavipes*, C and P., and *G. conicum* DC. The latter, however, is represented by so few specimens that its identity is not above suspicion. What has heretofore appeared in American catalogues as *G. fuscum* is found to differ strikingly from the European *fuscum*, and in the present paper is placed under that species as var. *globosum*, though it will probably sooner or later take its place as a distinct species. On anatomical grounds the following species of Rœstelia are recognized: *R. botryapites* Schw., *R. transformans* Ellis, *R. cancellata* Rebent., *R. cornuta* Fr., *R. lacerata* Fr., *R. penicillata* Fr., *R. hyalina* Cooke, and *R. aurantiaca* Pk. It appears, therefore, that each genus is represented by eight species, or, rejecting the doubtful *G. conicum* and uniting *R. lacerata* and *R. penicillata*, as is done by many writers, there are seven species of each.

Coming to the question of the genetic connection of the species of the two genera, it appears that Oersted has connected *G. clavariæforme* with *R. lacerata*, *G. fuscum* with *R. cancellata*, and *G. conicum* with *R. cornuta*. To confirm the conclusions of the Danish botanist, and to pair off the remaining species a series of careful cultures were made during the springs of 1876, 1877, 1878 and 1880, the sporidia of the various Gymnosporangia being sown on young plants or freshly gathered leaves of the Pomeæ which are attacked by Rœsteliæ. The results of these experiments are rather startling. Spermogonia followed very few of the sowings, and upon only two out of the seven plants chosen, namely, *Amelanchier Canadensis* and *Cratægus tomentosa*. On the former they appeared once after the sowing of *G. macropus*, but as æcidia were not found, and this plant supports three Rœsteliæ, it could not be determined to which species they belonged. On the other hand, the sowing of sporidia of *G. macropus* on *Cratægus tomentosa* was twice followed by the appearance of spermogonia,

and a like result was experienced in six experiments when the sporidia of *G. fuscum* var. *globosum* were used, and once when *G. biseptatum* was employed; but neither of these is the species which Oersted connected with *R. lacerata*, the common æcidium of this Cratægus. The geographical distribution of the species is also such as would not be expected if Oersted's views are correct; for while the typical *G. fuscum* and its supposed æcidial form *R. cancellata* are found in nearly equal quantity, *G. clavariæforme* is not common, yet its so-called æcidium, *R. lacerata*, is very abundant, occurring at points where the teleutosporic form has never been found; and *G. conicum*, if this species be accepted, is a southern form, while *R. cornuta* is distinctly northern in its range.

The negative results of many of Dr. Farlow's experiments, the unexpected indications of others, and the lack of correspondence in the distribution of species which have been supposed to be connected, joined to the very contradictory results of recent European culture, must, therefore, be taken as indicating that if Rœstelia and Gymnosporangium really are connected, the relations of the several species cannot be accepted as demonstrated; and there is no little probability that the spermogonia produced in successful experiments may arise from mycelium present in the leaves when they are collected, and stimulated to growth by the altered conditions under which they are placed. W. T.

5. *Regeneration of lost parts in the Squid, Loligo Pealei.* Extract from Trans. Connecticut Academy, vol. v, p. 318, Feb., 1881; by A. E. VERRILL.—"I have observed in this species, as well as in *Onmastrephes illecebrosus*, numerous instances in which some of the suckers have been torn off and afterwards reproduced. In such examples new suckers of various sizes, from those that are very minute up to those that are but little smaller than the normal ones, can often be found scattered among the latter, on the same individual. It seems to me possible that some of the specimens having the suckers on the tentacular arms unusually small, may have reproduced all those suckers, or still more likely, the entire arm.

"I have seen specimens of this species, and also of *O. illecebrosus*, which, after having lost the tips, or even the distal half of one or more of the sessile arms, have more or less completely reproduced the lost parts. In such cases the restored portion is often more slender and has smaller suckers than the normal arms, and where the old part joins the new there is often an abrupt change in size. Probably this difference would wholly disappear, after a longer time.

"An unquestionable and most remarkable example of the reproduction of several entire arms occurs in a small specimen taken off Newport, R. I., Aug., 1880. This has the mantle 70^{mm} long, dorsal arms 22^{mm}, 3d pair of arms 30^{mm}. The three upper pairs of arms are perfectly normal, but both the tentacular and both the ventral arms have evidently been entirely lost and then repro-

duced, from the very base. These four arms are now nearly perfect in form, but are scarcely half their normal size on the left side, and still smaller on the right side. The left tentacular arm is only 24^{mm} long, and very slender, but it has the normal proportion of club, and the suckers, though well formed, are diminutive, and those of the two median rows are scarcely larger than the lateral ones, and delicately denticulated. The right tentacular arm is less than half as long (12^{mm}), being of about the same length as the restored ventral one of the same side; it is also very slender and its suckers very minute and soft, in four equal rows. The right ventral arm is only 14^{mm} long; the left one 15^{mm} long: both are provided with very small but otherwise normal suckers.

"In another specimen from Vineyard Sound, a female, with the mantle about 150^{mm} long, one of the tentacular arms had lost its club, but the wound had healed and a new club was in process of formation. This new club is represented by a small tapering acute process, starting out obliquely from the stump, and having a sigmoid curvature; its inner surface is covered with very minute suckers. The other arms are normal."

It seems probable that some of the nominal European species of *Loligo* that have been based on the smaller size of the tentacular arms or of the suckers are due to similar instances of regeneration of these parts.

IV. Astronomy.

1. *Reports on the Total Solar Eclipses of July 29th, 1878, and January 11th, 1880.* Washington, 1880. 4°, pp. xiv and 416, with about sixty plates.—This volume is published by the Naval Observatory, the arrangement and printing being under the care of Professor Harkness. The several reports are in the words of the observers, and the aim has been to reproduce as exactly as possible in the prints *fac similes* of the drawings.

Many of the principal results of the observations have in one form or another been previously given to the public. But the full meaning of them can only be deduced by careful comparison of these records with previous eclipse observations, and specially with the collection lately made by Mr. Ranyard. The reports are from over sixty observers, among whom are Professors Harkness, Newcomb, Watson, Holden, Hastings, Langley, Hall, Wright, Eastman, and Messrs. Trouvelot, Hill, and Rogers. Perhaps it is the observations upon the corona that will be regarded as of the greatest importance, as the larger part of the observers gave their attention to it.

2. *Report on the Polarization of the Corona during the total Solar Eclipse of July* 29, 1878; by A. W. Wright, Ph.D., Yale College.—This memoir forms pp. 261–281, with plates 24–28, of the report of the solar eclipse of July 29, 1878, issued from the U. S. Naval Observatory, Washington (see above). Professor Wright first gives an account of some preliminary experiments with artificial coronas, which served to make clear the special

difficulties to be encountered in the actual observations made and to test the efficiency of the means adopted. The forms of apparatus employed are described in full, including, among other things, a polarimeter of novel construction, and which proved most efficient in the actual work. The observations made during the eclipse are then given in detail. The results of the various observations made are summarized as follows:

(1) With respect to the character of the polarization, the observations made by three independent methods agree in showing that it is radial. The photographs appear to indicate some deviation of the planes of polarization from the direction of the radii, in four regions situated some 20° from the poles, where they seem to be deflected outward; that is, away from the solar axis. The amount of the deflection as well as its existence is subject to some uncertainty, for the reason that it may possibly be explained by certain peculiarities in the distribution of the intensity of polarization. The effect is more strongly marked in the northern hemisphere.

(2) The polarization decreases from the moon's limb outward, as shown both by the photographs and the polarimetric measurements. The latter show that for a space vertically beneath the sun, and distant between 4′ and 10′ from the moon's limb, it amounts to 12 per cent, and between 12′ and 18′ to 6·8 per cent, being still less for a point more remote.

(3) Around the circumference the intensity appears to be approximately uniform, except for a region about the poles, extending 20° each way, where it is somewhat greater.

(4) The observations afford no answer to the question whether the polarization is confined to the light which gives the continuous spectrum, inasmuch as the expected bright line spectrum was too faint to be observed.

(5) The conclusion seems to be warranted that the passage of the polarized rays through the terrestrial atmosphere produces but very slight effects, and none that can be definitely recognized in the results of the observations. The influence of polarization in the rays reflected by the atmosphere was inappreciable. The diffuse light of the sky may have had a slight share in diminishing the apparent polarization at the extreme outer border of the corona by dilution, but it is doubtful whether it was sufficient to make it necessary to take it into consideration.

3. *Memoirs of the Royal Astronomical Society of London*, Vol. XLI, 1879, with eighteen plates.—This thick volume is exclusively devoted to the solar eclipses, and is prepared by Mr. Ranyard at the suggestion of the Astronomer Royal. The plan of the work is to bring systematically together in separate chapters all the observations of solar eclipses, classifying them according to subjects. The volume contains 44 chapters, each devoted to a special subject, and includes all the eclipses that have been well observed down to, but not including, that of 1878. There is a very large amount of new matter, especially of details of the

structure of the corona as derived from the photographs of the eclipse of 1871. The plates show that this appendage of the sun is much more complicated in form than has been hitherto supposed.

V. Miscellaneous Scientific Intelligence.

1. *Soldering by Compression.*—M. W. Spring, after describing the apparatus he used, gives the following results in an elaborate research published in the Bulletin of the Brussels Academy of Sciences for 1880 (xlix, 323):

Powdered lead became perfectly solid, like a block obtained from fusion, under a pressure of 2,000 atmospheres, and with a pressure of 5,000, run like a liquid; bismuth became perfectly solid under a pressure of 6,000; tin, 3,000; zinc, 5,000; aluminum, 6,000; copper, like aluminum; antimony with more difficulty than aluminum, the compacted mass obtained under 5,000 atmospheres being more or less pulverulent at center; platinum, not consolidated.

Powdered transparent monoclinic sulphur became perfectly solid under a pressure of 5,000 atmospheres, but was changed to orthorhombic sulphur, which has higher density than the monoclinic; orthorhombic sulphur, under a pressure of 3,000; graphite, 5,500, becoming as solid as the best native graphite.

Alumina, in powder, obtained by precipitation of aluminum sulphate by ammonium carbonate, became perfectly solid and *translucent* with a *tendency to transparency* at 5,000 atmospheres, and had a bluish reflection, but without great hardness; at 5,000, it run like a liquid so that it could not be subjected in the apparatus to higher pressure.

Silica, in powder (using fine sand, and also precipitated silica), gave only a commencement of union under any pressure used. Gypsum became only imperfectly solid, it breaking early into bits. Chalk, under a pressure of 5,000 atmospheres, became as solid as the ordinary chalk crayons; iceland spar, under 6,000, became harder than chalk, but not quite firm. Precipitated lead carbonate gave no result; glass, no satisfactory result, under a pressure of 6,000 atmospheres.

Bituminous coal in powder became perfectly solid under a pressure of 6,000 atmospheres, and may be moulded at this pressure with the greatest facility, being plastic, "which explains how the flexing of ancient coal-beds became possible." Peat, under a pressure of 6,000 atmospheres, became a brilliant black solid, hard and looking like coal, with its organic texture completely obliterated; it was also plastic, "illustrating thereby the origin of coal," and showing that heat was not needed to produce it; moreover, it yielded a coke like that of mineral coal.

Charcoal (obtained by calcining sugar) underwent no change; and the same was true of animal black.

The author gives results from trials with various other substances—83 in all, and ends his paper with some general conclusions.

2. *Geodesy*, by Col. A. R. CLARKE, R.E., F.R.S., etc. Oxford, 1880. 8°, 356 pp.—This work supplies a want long seriously felt in the English literature of Geodesy. Its late date gives it the great advantage of comprising the most recent improved methods in observation and theoretical discussion. The treatment of the subject is simple, pertinent and condensed, while illustrations are gathered with rare discrimination from the governmental reports of all nations now prosecuting geodesic operations. Col. Clarke, who has long been connected with the Trigonometrical Survey of Great Britain, and of late years has had charge of its Geodesy, adds to the general didactic treatment of the subject a brief discussion of the figure of the earth as determined from geodesic measurements and pendulum experiments, showing that the ratio of the polar and equatorial axes of the terrestrial spheroid does not differ sensibly, so far as can be ascertained from existing data. By both methods the ratio of the polar and equatorial diameters is now found to be about 292 : 293. This work should be in the hands of every student of geodesy. J. E. H.

3. *Memorial volume of Benjamin Peirce.*—The editor of the Harvard Register, Mr. Moses King, has published, in tasteful form, a little volume designed as a memorial of Professor Peirce. It contains, after the introductory note by the editor, the notice of Professor Peirce published in the Register in May, 1880, a brief statement of his final illness and of the services at the funeral, with the address of the Rev. J. F. Clarke, delivered at that time; it also contains obituary notices reprinted from other publications, several memorial sermons, and a poem by Dr. Holmes. An excellent portrait of the eminent Harvard mathematician forms the frontispiece of the volume.

4. *The Atomic Theory*, by AD. WURTZ, translated by E. Cleminshaw. 344 pp. 8vo. New York, 1881 (International Scientific Series—D. Appleton & Co.).—Prof. Wurtz has given a very clear and simple statement of the historical development and present state of the atomic theory. The book is well adapted for the class of readers for which it is especially designed, and anyone, even with but comparatively slight previous training, may gain from it a knowledge of the general principles of chemical philosophy now accepted.

5. *The Third International Geographical Congress.*—The first International Congress was held at Antwerp in 1871, and the second at Paris, in 1875. The third will be held at Venice during the week commencing on the 15th of September next. The Geographical Exhibition will be opened Sept. 1st, and close not before Oct. 1. The Congress will be divided into seven sections: (1) Mathematical Geography, Geodesy, Topography; (2) Hydrography, Maritime Geography; (3) Physical Geography, Meteorology, Geology, Botany, Zoology; (4) Historical, Ethnographical, Philological Geography, History of Geography; (5) Economical, Commercial, Statistical Geography; (6) Methodology, Tuition of Geography; (7) Exploring and Geographical Expeditions.

Correspondence should be addressed to the Managing Committee of the Third International Geographical Congress, 26 Via del Collegio Romano, Rome. Information may also be obtained at the office of the English Monthly Review, MINERVA, 56 Piazza Montecitorio, Rome.

The President of the Italian Geographical Society is Prince Di Teano, and the Chief Secretary, G. Dalla Vedova.

6. *Illinois State Laboratory of Natural History.*—Bulletin No. 3, consisting of 160 pages 8vo, contains the results of extended personal observations by Mr. S. A. FORBES, occupying 130 pages, on the food of fishes and birds, besides notes, by the same, on Insectivorous Coleoptera; and also a paper by F. M. WEBSTER, on the food of predaceous beetles.

Reports on the results of dredging, under the supervision of A. Agassiz, in the Caribbean Sea, 1878–79, along the Atlantic coast of the United States during the summer of 1880, by the United States Coast Survey steamer "Blake," Commander J. R. Bartlett, U. S. N., commanding. Two reports have recently been published (Dec., 1880) in vol. viii of the Bulletin of the Museum of Comparative Zoology of Harvard College: Études préliminaires sur les Crustacés, par M. Alph. Milne-Edwards. 1re partie. pp. 1 to 68, with 2 plates; the other, A Preliminary Report on the Echini, by A. Agassiz, pp. 69 to 84.

Bulletin of the Buffalo Society of Natural Sciences, vol. iii, No. 5, contains, besides an important archæological paper, a description of a new Argulus by D. S. Kellicott, and a new Check-list of N. A. Sphingidæ, by A. R. Grote.

OBITUARY.

Dr. JOHN J. BIGSBY, F.R.S., founder of the Bigsby Medal of the Geological Society, died at Gloucester Place, on the 10th of February, at the age of eighty-eight. Dr. Bigsby was long a resident of Canada, and a very early contributor on geological subjects to this Journal. His first article appeared in the second volume, in 1820. In 1868 he published his "Thesaurus Siluricus: The Flora and Fauna of the Silurian Period," and in 1878, just three years since, his "Thesaurus Devonico-Carboniferus: The Flora and Fauna of the Devonian and Carboniferous Periods." Both works involved a vast amount of labor, and evinced that his energies and his interest in his favorite science continued long after the time when most men begin to rest from their work.

Professor E. BORICKY, of Prague, eminent in mineralogy and lithology, and the author of several valuable memoirs on the igneous rocks of Bohemia, died on the 27th of January at the age of forty.

Professor JAMES TENNANT, long connected with King's College, London, and well known as an active collector of minerals and gems, died recently at the age of seventy-three.

Mr. JOSEPH A. CLAY, a successful amateur mineralogist and a prominent member of the Philadelphia bar, died on March 18th, in his seventy-fifth year.

APPENDIX.

ART. XLI.—*A New Order of Extinct Jurassic Reptiles* (*Cœluria*); by O. C. MARSH. With Plate X.

THE remains previously described by the writer, and named *Cœlurus fragilis*,* prove on further investigation to represent a new group of much interest. Portions of the skeleton of some ten or twelve different individuals have now been secured from the same horizon in the upper Jurassic that yielded the type specimen, and all are in the Museum of Yale College. A study of these remains, which are mostly vertebræ, shows clearly that they differ widely from the corresponding parts in any of the known orders of reptiles, living or extinct, but the nearest affinities of the new group cannot as yet be determined with certainty.

The most marked feature in all the known remains of *Cœlurus* is the extreme lightness of the bones, the excavations in them being more extensive than in the skeleton of any known vertebrate. In the vertebræ, for example, the cavities are proportionally larger than in either Pterodactyls or Birds, the amount of osseous tissue retained, being mainly confined to their exterior walls. In Plate X, a cervical, dorsal, and caudal vertebra are figured, with transverse sections of each to illustrate this point. Even the ribs of *Cœlurus* are hollow, with well defined walls to their large cavities. No limb bones of *Cœlurus* are as yet known with certainty, and those provisionally referred to that genus are, owing to their fragility, too imperfectly preserved for accurate determination.

The vertebræ of *Cœlurus* now known are from various parts of the column, and most of them are in good condition. Three of these are represented natural size in Plate X. The cervicals are large and elongate, and were locked together by strong zygapophyses. The first three or four behind the axis had the front articular face of the centrum somewhat convex, and the posterior one deeply concave. All the other cervicals were biconcave, and this was the case also with the vertebræ of the trunk and tail. The articular faces of the cervicals are

* This Journal, vol. xviii, p. 504, Dec., 1879.

inclined, showing that the neck was curved. The anterior cervical ribs were coössified with the centra, as in Birds. Figures 1, 1*a* and 1*b*, Plate X, represent a cervical vertebra from near the middle of the neck. The cavities in the cervicals are connected with the soutide by comparatively large pneumatic openings. The neural canal is very large, and traces of the neuro-central suture are distinct.

The dorsal vertebræ of *Cœlurus* are much shorter than the cervicals. The centra have a deep cup in front, and a shallow concavity behind. These articular faces are nearly at right angles to the axis of the trunk. The neural spine is elevated, and compressed. The transverse processes are elongate. The ribs preserved have undivided heads. A posterior dorsal is represented in Plate X, figures 2, 2*a* and 2*b*. The suture of the neural arch is distinct in this specimen. The foramina leading to the cavities in the dorsal vertebræ are quite small.

The caudal vertebræ are elongate, and very numerous. They are all biconcave, and all appear to have been without chevron bones. An anterior caudal is figured in Plate X, and the accompanying section shows the inner structure. In most of the caudals, the neuro-central suture has entirely disappeared.

Taking the vertebral column of *Cœlurus* as a whole it clearly indicates a large and powerful neck, a trunk of moderate size, and a very long weak tail. So far as the vertebræ suggest anything in regard to the limbs, those in front should be as large or larger than those behind, as in Pterodactyls, and not the reverse, as in animals that leap.

The characters given above prove conclusively that *Cœlurus* cannot be placed in any known order. Its remains preserved suggest resemblances to Dinosaurs, to Pterodactyls, and more remotely to Birds, and it is apparently a generalized Sauropsid, which, when fully investigated, may serve to bridge over some of the present breaks in the lines of descent. The sum of its known characters indicates that it is a reptile and not a bird. Its structure so far as known presents more similarity to that of Dinosaurs, than Pterodactyls, but for its nearer affinities we must await the discovery of further remains. An arboreal Dinosaur would not surprise anatomists familiar with the marvelous diversity of forms in that comprehensive group of reptiles.

The order represented by the remains here described may be termed *Cœluria*, and the family, *Cœluridæ*, from the type genus *Cœlurus*. The remains now known are all from the Atlantosaurus beds of the upper Jurassic of Wyoming Territory.

Yale College, New Haven, March 14th, 1881.

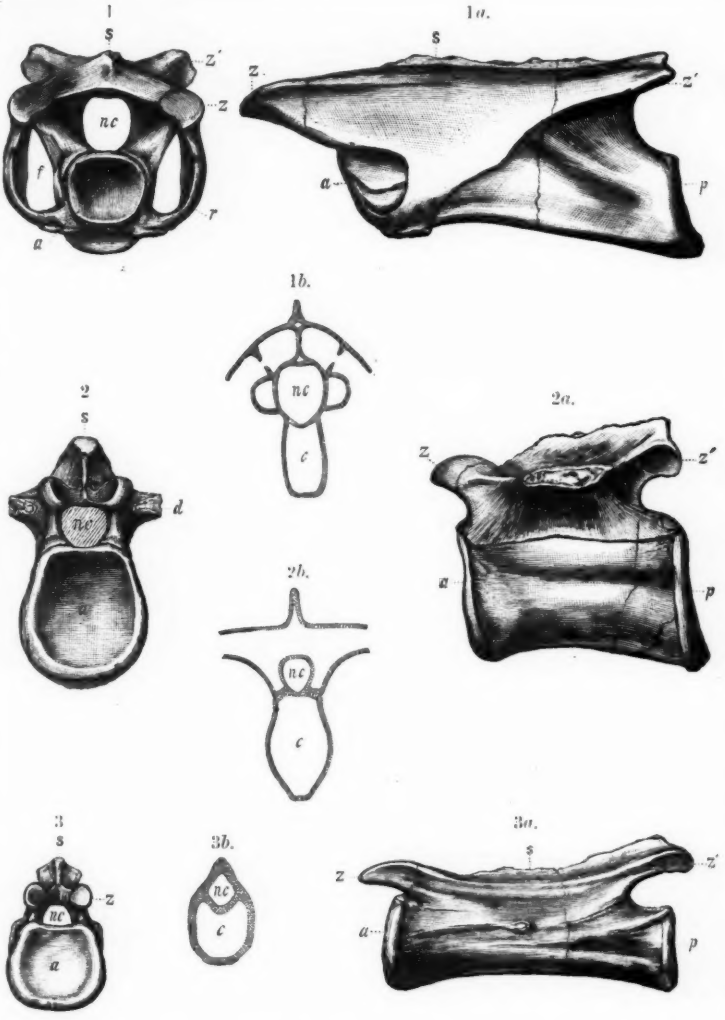


FIGURE 1.—Cervical vertebra of *Cœlurus fragilis* Marsh; front view. 1*a*. side view; 1*b*. transverse section of same vertebra.

FIGURE 2.—Dorsal vertebra of *Cœlurus fragilis;* front view. 2*a*. side view; 2*b*. transverse section of same.

FIGURE 3.—Caudal vertebra of *Cœlurus fragilis;* front view. 3*a*. side view; 3*b*. transverse section of same.

a. anterior; *p*. posterior; *c*. cavity; *f*. lateral foramen; *nc*. neural canal; *r*. coössified rib; *s*. neural spine; z. anterior zygapophysis; *z'*. posterior zygapophysis.

All the figures are of the natural size.

Art. XLII.—*Discovery of a Fossil Bird in the Jurassic of Wyoming;* by O. C. Marsh.

The oldest Birds hitherto known from American strata are the toothed forms (*Odontornithes*), from the middle Cretaceous deposits, on the eastern flanks of the Rocky Mountains. In Europe, three specimens of the genus *Archæopteryx* have been found in the Jurassic, but from older formations no remains of this class have been brought to light. The writer has made a careful search for fossil Birds in the Jurassic beds of the West, and has been rewarded by the discovery of various remains, some of which are sufficiently characteristic for determination. The most important of these specimens is described below:

Laopteryx priscus, gen. et sp. nov.

The type specimen of the present species is the posterior portion of the skull, which indicates a bird rather larger than a Blue Heron (*Ardea herodias*). The braincase is so broken, that its inner surface is disclosed, and in other respects the skull is distorted, but it shows characteristic features. The bones of the skull are pneumatic. The occipital condyle is sessile, hemispherical in form, flattened and slightly grooved above. There is no trace of a posterior groove. The foramen magnum is nearly circular, and small in proportion to the condyle. Its plane coincides with that of the occiput, which is slightly inclined forward. The bones around the foramen are firmly coössified, but the supra-occipital has separated somewhat from the squamosals and parietals. Other sutures are more or less open. On each side of the condyle, and somewhat below its lower margin, there is a deep rounded cavity, perforated by a pneumatic foramen.

The cavity for the reception of the head of the quadrate is oval in outline, and its longer axis, if continued backward, would touch the outer margin of the occipital condyle. This cavity indicates that the quadrate had an undivided head. The braincase was comparatively small, but the hemispheres were well developed. They were separated above by a sharp mesial crest of bone. A low ridge divided the hemispheres from the optic lobes, which were prominent.

The following measurements indicate the size of the specimen:

Width of skull across occiput (approximate)	24·mm
Transverse diameter of occipital condyle,	5·
Vertical diameter,	4·
Width of foramen magnum,	5·
Height,	6·
Distance from occipital condyle to top of supra-occipital,	11·

In its main features, the present specimen resembles the skull of the *Ratitæ*, more than that of any existing birds. Other parts of the skeleton will doubtless show still stronger reptilian characters.

In the matrix attached to this skull, a single tooth was found, which most resembles the teeth of birds, especially those of *Ichthyornis*. It is probable that *Laopteryx* possessed teeth, and also biconcave vertebræ.

The specimen here described, and others apparently of the same species, were found in the upper Jurassic of Wyoming Territory, in the horizon of the Atlantosaurus beds.

Yale College, New Haven, March 18, 1881.

ART. XLIII.—*Note on American Pterodactyls;* by O. C. MARSH.

THE Jurassic deposits of this country, up to the present time, have yielded only a single species of *Pterosauria*—*Pterodactylus montanus* Marsh.* The known remains are all fragmentary, but some of them indicate the general characters of the species and genus. Among the remains now in the Yale Museum are portions of the wing bones, including the characteristic wing metacarpal and first phalanx. These bones, although pneumatic, show much thicker walls than the corresponding bones of other Pterodactyls, even those from the same formation in Europe, thus suggesting a less degree of specialization. The size of these specimens indicates a spread of wings about five or six feet. The scapula and coracoid do not appear to have been ankylosed. The vertebræ referred provisionally to this species are procœlian. The teeth found near the remains, and apparently belonging with them, are elongate, and more rounded than in most Pterodactyls.

The genus represented by these remains appears to be distinct from *Pterodactylus*, and may be termed *Dermodactylus*. The only known species will hence be *Dermodactylus montanus*.

AMERICAN CRETACEOUS PTERODACTYLS.

The representatives of the *Pterosauria* from the Cretaceous of this country all appear to be destitute of teeth, and have therefore been placed by the writer in the new order *Pteranodontia*, from the type genus *Pteranodon*. These are mostly of gigantic size, some having a spread of wings of nearly or quite twenty-five feet. These reptiles have one remarkable feature in the skeleton, unknown in any other animals. To aid the

* This Journal, vol. xvi, p. 233, Sept. 1878.

powerful wings in flight, the pectoral arch is strengthened, (1), by the anchylosis of several vertebra: (2) by the robust scapulæ articulating on opposite sides of the common neural spine of these vertebræ.* This is virtually a repetition of the pelvic arch, on a much larger scale. One genus of American Cretaceous Pterodactyls (*Nyctodactylus*) was apparently without this feature.†

In the same geological horizon with the gigantic forms (Pteranodon beds), the remains of a single small Pterodactyl have been found. This animal was more diminutive than the Jurassic species, having a spread of wings not more than three or four feet. The jaws were proportionally more slender than in the larger Cretaceous species, and no teeth have been found with them. The humerus had a small head, and an enormous radial crest, which curved downward. The scapula and coracoid were firmly ankylosed. Some of the trunk vertebræ have very long transverse processes, or ankylosed ribs, curved backward. Some dimensions of this specimen are as follows:

Length of humerus,	62mm
Greatest diameter of head,	12
Transverse diameter across radial crest,	30
Greatest diameter of distal end,	16
Vertical diameter of humeral glenoid cavity,	13
Transverse diameter,	6

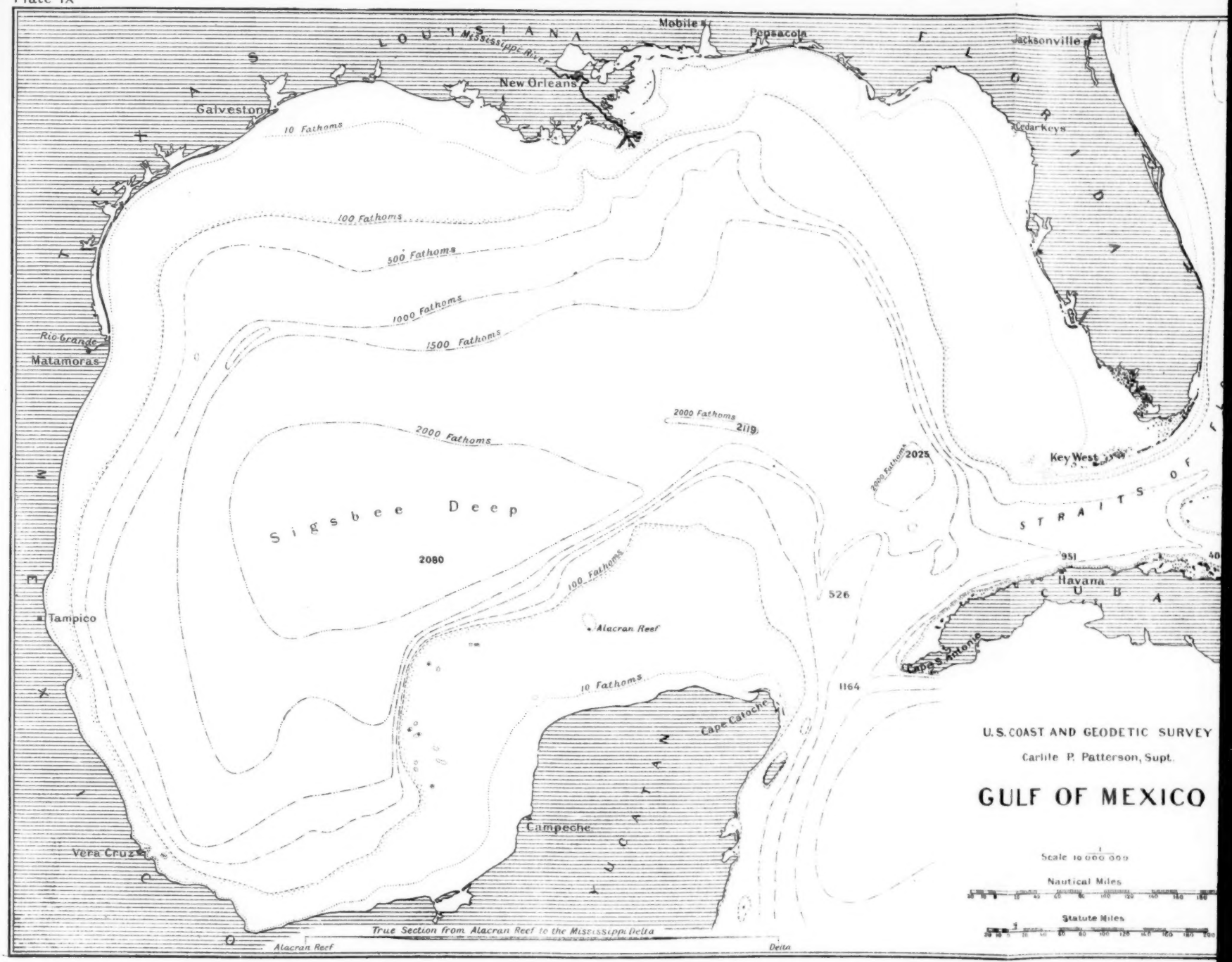
This species may be called *Pteranodon nanus*. Its known remains were found by Mr. S. W. Williston, in the Middle Cretaceous of Western Kansas.

Yale College, New Haven, Conn., March 21st, 1881.

* This peculiar neural spine with its opposite articular facets seems to be present also in some of the English Cretaceous Pterodactyls. Owen figured and described it as a "frontal bone (?)", (Pal. Soc. 1851, Sup. I, p. 12, Plate IV, figs. 6, 7 and 8), and Seeley regarded it as a "? vomer." (Ornithosauria, p. 88, Plate XII, figs. 15 and 16.)

† The name *Nyctosaurus*, applied by the writer to this group, appears to have been preoccupied, and hence may be replaced by *Nyctodactylus*. The only species known is *Nyctodactylus gracilis*.

Plate IX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Vera Cruz
MEXICO
True Section from Alacran Reef to the Mississippi Delta
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U.S. COAST AND GEODETIC SURVEY
Carlile P. Patterson, Supt.
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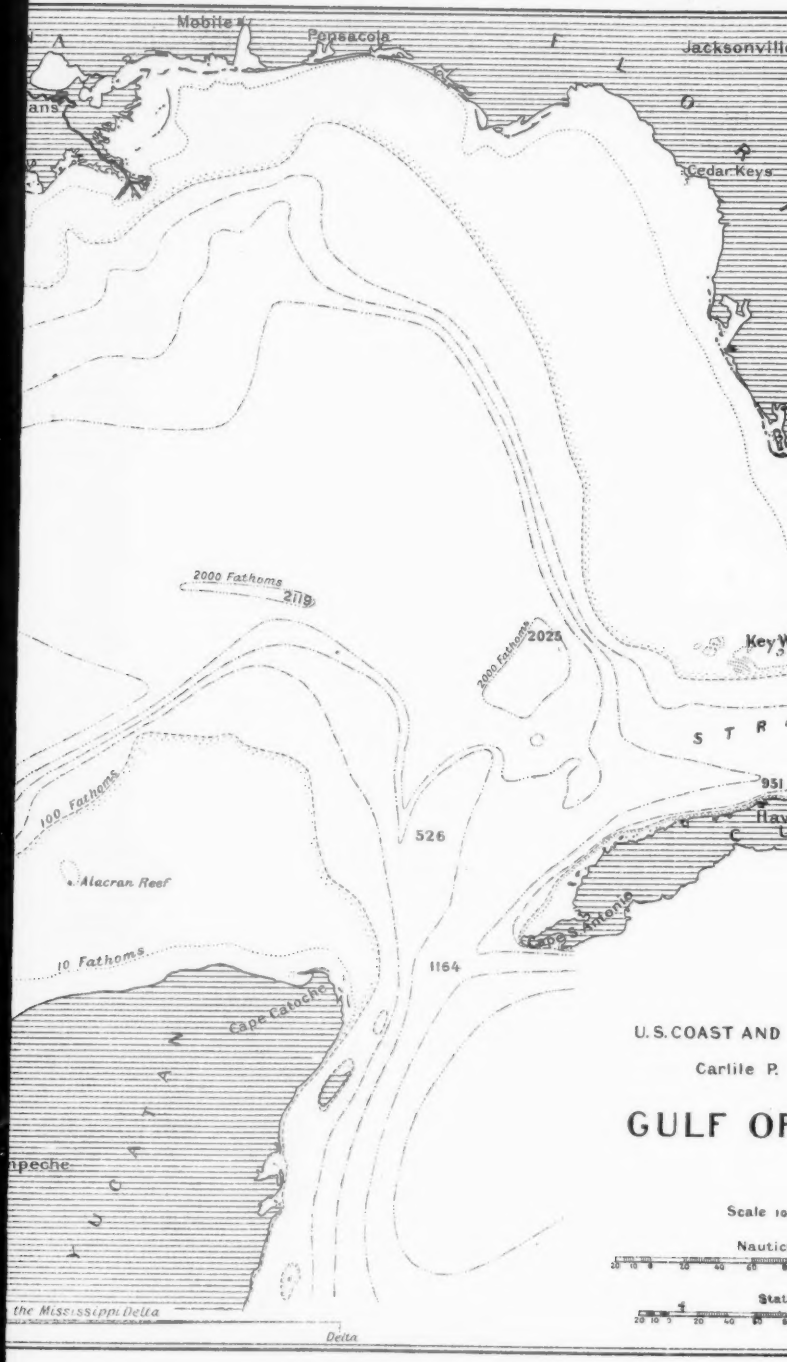
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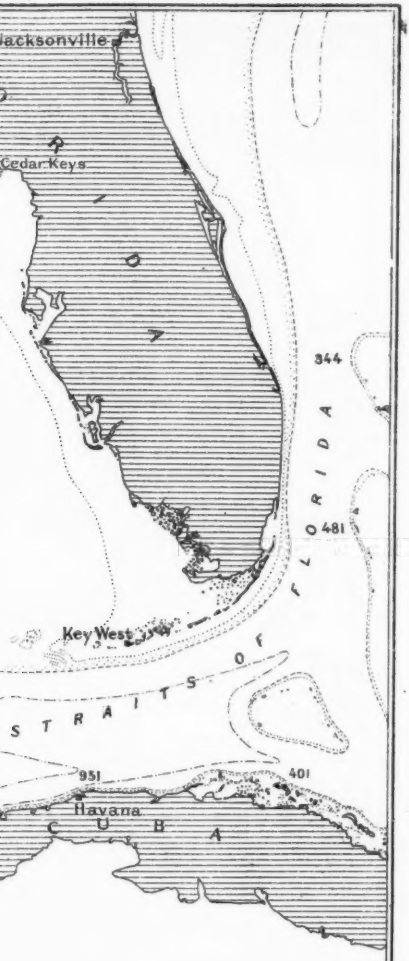

COAST AND GEODETIC SURVEY

Carlile P. Patterson, Supt.

GULF OF MEXICO

Scale 1 to 1 000 000

Nautical Miles

Statute Miles

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